JC18 Rec'd PCT/PTO 22 JAN 2002

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 USC 371

International Application No.: PCT/BE00/00086
International Filing Date: July 19, 2000
Priority Date Claimed: July 23, 1999
Title of Invention: METHOD AND APPARATUS FOR HIGH-SPEED SOFTWARE RECONFIGURABLE CODE DIVISION MULTIPLE ACCESS COMMUNICATION
Applicants for DO/EO/US: Nico Lugil, Eric Bourghs, Sébastien Louveaux, Carl Mertens, Lieven Philips, Jurgen Vandermot and Jan Vanhoof

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. (X) This is a **FIRST** submission of items concerning a filing under 35 USC 371.

2. (X) This express request to begin national examination procedures (35 USC 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 USC 371(b) and PCT Articles 22 and 39(1).

3. (X) A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.

4. (X) A copy of the International Application as filed (35 USC 371(c)(2))

   a) () is transmitted herewith (required only if not transmitted by the International Bureau).
   b) (X) has been transmitted by the International Bureau.
   c) (X) a copy of Form PCT/IB/308 is enclosed.
   d) () is not required, as the application was filed in the United States Receiving Office (RO/US).

5. (X) Amendments to the claims of the International Application under PCT Article 19 (35 USC 371(c)(3))

   a) () are transmitted herewith (required only if not transmitted by the International Bureau).
   b) () have been transmitted by the International Bureau.
   c) () have not been made; however, the time limit for making such amendments has NOT expired.
   d) (X) have not been made and will not be made.

6. (X) A copy of the International Preliminary Examination Report with any annexes thereto, such as any amendments made under PCT Article 34.

7. (X) An Information Disclosure Statement under 37 CFR 1.97 and 1.98 with Pto Form-1449 and four (4) references.

8. (X) A FIRST preliminary amendment.

9. (X) International Application as published (cover sheet only).

10. (X) International Search Report.

11. (X) Twenty-six (26) sheets of drawings.

12. (X) A return prepaid postcard.

13. (X) The following fees are submitted:

				FEES
	BASIC FEE			$890
CLAIMS	**NUMBER FILED**	**NUMBER EXTRA**	**RATE**	
Total Claims	38 - 20 =	18 ×	$18	$324
Independent Claims	3 - 3 =	0 ×	$84	$0
Multiple dependent claims(s) (if applicable)			$280	$0
	TOTAL OF ABOVE CALCULATIONS		$1,214	
	TOTAL NATIONAL FEE			$1,214
	TOTAL FEES ENCLOSED			$1,214

14. (X) The fee for later submission of the signed oath or declaration set forth in 37 CFR 1.492(e) will be paid upon submission of the declaration.

15. (X) A check in the amount of $1,214 to cover the above fees is enclosed.

16. (X) The Commissioner is hereby authorized to charge only those additional fees which may be required, now or in the future, to avoid abandonment of the application, or credit any overpayment to Deposit Account No. 11-1410.

SEND ALL CORRESPONDENCE TO:

John M. Carson
Reg. No. 34,303
Customer No. 20,995

H:\DOCS\MOH\MOH-6801 DOC ad
012102

10/048142
531 Rec'd PCT 22 JAN 2002

VANM244.001APC

PATENT #4/A

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant	:	Lugil, et al.	Group Art Unit Unknown
Appl. No.	:	Unknown	
Filed	:	Herewith	
For	:	METHOD AND APPARATUS FOR HIGH-SPEED SOFTWARE RECONFIGURABLE CODE DIVISION MULTIPLE ACCESS COMMUNICATION	
Examiner	:	Unknown	

PRELIMINARY AMENDMENT

Assistant Commissioner for Patents
Washington, D.C. 20231

Dear Sir:

Prior to the examination of the above-captioned application, please amend the application as follows:

IN THE SPECIFICATION:

Please amend the specification published as International Application WO 01/08314, as follows:

Please delete the paragraphs starting on page 1, line 16 and ending on page 2, line 24.

Please add the following paragraph on page 2, line 25:

Description of the Related Technology

A communication device, for example, for Wideband Code Division Multiple Access (W-CDMA) is configured to operate in accordance with a predetermined telecommunication

Appl. No. : **Unknown**
Filed : **Herewith**

standard and predetermined parameters. The communication device typically has a digital signal processor (DSP) that allows it to adapt to changes of the physical layer.

There is therefore a need for a W-CDMA system, which allows the implementation of various telecommunication standards, and various applications realizable according to these standards, without the need for a powerful DSP processor for the flexible part of the physical layer. Further, there is a need for a W-CDMA apparatus that provides for various fading channel circumstances.

Please amend the heading on page 2, line 14 as follows:

Summary of Certain Inventive Aspects

Please delete the heading on page 2, line 26.

Please amend the heading on page 9, line 31 as follows:

Brief Description of the Drawings

Please amend the heading on page 40, line 1 as follows:

WHAT IS CLAIMED IS:

IN THE CLAIMS:

Please cancel Claims 1-39 without prejudice.

Please add the following new claims:

40. (New) A communication device for W-CDMA signal transmission and reception, which is software configurable, comprising:

a W-CDMA transmitter comprising at least one of a RAM and registers;

a W-CDMA receiver comprising at least one of a RAM and registers;

a signal acquisition circuit

a digital circuit for phase unbalance precompensation comprised in said W-CDMA transmitter, said digital circuit comprising:

an input register holding a compensation angle; and

section adapted to perform arithmetic calculations to acquire a change of an I, Q angle by the compensation angle.

41. (New) The communication device of Claim 40, further comprising a circuit for noise and interference estimation, said circuit comprising:

means to acquire a programmable number of absolute value accumulations at a chip rate or an oversampled chip rate; and

a programmable low pass filter to average the noise and interference estimations.

42. (New) The communication device of Claim 40, further comprising a circuit for initial synchronization, said circuit comprising:

a matched filter, energy calculation and accumulating RAM for slot synchronization;

a set of correlators for frame synchronization and code group identification;

an energy estimation block; and

maximum detection means readable by a microprocessor subsystem.

43. (New) The communication device of Claim 40, further comprising circuitry to generate packet data transmission, said circuitry comprising:

a buffer storing data and activity bits;

I, Q spreaders and gain control means;

scrambling code generator and scrambling means; and

means for packet timing through RX frame edge triggering.

44. (New) The communication device of Claim 43, wherein the communication device is configured for RACH transmission in UMTS/FDD.

45. (New) The communication device of Claim 40, further comprising a processor.

46. (New) The communication device of Claim 45, wherein the processor is configured to reconfigure the communication device.

47. (New) The communication device of Claim 45, wherein the processor controls at least one of the RAM registers of said W-CDMA signal transmitter and receiver.

48. (New) The communication device of Claim 45, wherein the transmitter comprises a first programmable pulse shaping filter, and wherein the receiver comprises a second programmable pulse shaping filter.

Appl. No. : **Unknown**
Filed : **Herewith**

49. (New) The communication device of Claim 48, wherein the pulse shaping filters are programmable to perform GMSK filtering, and wherein said transmitter and receiver are arranged to interface with a GSM front-end.

50. (New) The communication device of Claim 49, wherein the processor performs a GSM protocol stack.

51. (New) The communication device of Claim 42, wherein the communication device is configured for at least one of waveform transmission, reception and acquisition of signals selected from the group consisting of UMTS, Satellite UMTS, Galileo, GPS, IS-2000, IMT-2000, CDMA2000, IS-95, 3GPP, 3GPP2 and ARIB signals.

52. (New) The communication device of Claim 40, wherein said transmitter comprises one or more elements selected from the group consisting of:

synchronization hardware to slave transmit start epochs to events external to the transmitter;

a burst generator for realizing discontinuous transmissions;

a QPN channel containing one or more spreaders with their own amplification of the output;

a combiner to accumulate the QPN channel output;

a PN code generator;

a scrambling code generator;

a scrambler;

a combiner which accumulates the scrambling code output;

a pulse shaping oversampling filter; and

an NCO and upconverter for carrier precompensation.

53. (New) The communication device of Claim 52, wherein the PN code generator is realized as a RAM in which PN codes are downloaded under control of the processor.

54. (New) The communication device of Claim 52, wherein the scrambling code generator is realized as a programmable Gold Code generator.

55. (New) The communication device of Claim 52, wherein the QPN channel is arranged to execute UMTS forward or return link transmission.

56. (New) The communication device of Claim 52, wherein an amplification of the spreader output is arranged to perform transmit power control.

Appl. No. : Unknown
Filed : Herewith

57. (New) The communication device of Claim 40, wherein the transmitter comprises a time interpolator to perform sub-chip time alignments.

58. (New) The communication device of Claim 40, wherein the transmitter is arranged for multi-code transmission.

59. (New) The communication device of Claim 40, wherein the receiver comprises:

a pulse shaping filter;

an optional level control block;

a demodulator assigned to track multi-path components received from one base station; and

a reference demodulator for S/ (N+I) measurements.

60. (New) The communication device of Claim 59, wherein said receiver further comprises a downconverter prior to said pulse shaping filter in order to interface at a front-end at an intermediate frequency.

61. (New) The communication device of Claim 59, wherein the receiver is arranged for execution of at least one of UMTS, Satellite UMTS, Galileo, GPS, IS-2000, IMT-2000, CDMA2000, IS-95, 3GPP, 3GPP2 and ARIB forward link and return link waveforms.

62. (New) The communication device of Claim 59, wherein the level control block comprises:

a programmable shifter to perform coarse grain dynamic control;

a programmable multiplier to perform fine grain dynamic control;

an overflow counter operating on a most significant bit and a second most significant bit; and

a saturation logic to clip a result from the multiplier.

63. (New) The communication device of Claim 59, wherein the level control block is operated in a runtime control loop by the processor.

64. (New) The communication device of Claim 59, wherein the demodulator comprises:

a Rake filter producing a signal at a chip rate which is a coherent accumulation of channel corrected multipath components resulting from one base station;

a tracking unit using said signal at the chip rate for descrambling and despreading a plurality of waveform channels; in which said Rake filter comprises:

a FIFO to buffer samples at chip rate coming from said level control block;

a delay line containing a plurality of registers, an input of the delay line being connected to an output of said FIFO;

a plurality of finger blocks, inputs of said finger blocks being connected to programmable tap positions on said delay line; and

a summator of complex outputs of said finger blocks at chip rate.

65. (New) The communication device of Claim 64, wherein the finger blocks are respectively grouped in a late multipath group and an early multipath group, the Rake filter being arranged to accumulate the energies of the outputs of said late multipath group and said early multipath group, and to use these accumulated values to feed the time error detector of the DLL for time tracking.

66. (New) The communication device of Claim 64, wherein the Rake filter comprises memories to hold at least one of a spreading code for a channel correction Pilot, a scrambling code for a channel correction Pilot, a channel correction Pilot symbol modulation, and a channel correction Pilot symbol activities.

67. (New) The communication device of Claim 66, wherein the memories are controlled by the processor.

68. (New) The communication device of Claim 66, wherein the finger block comprises:

a channel correction Pilot descrambler;

a channel correction Pilot despreader;

a channel correction Pilot filter, first performing a coherent channel correction Pilot symbol accumulation over a programmable number of steps, and secondly producing a weighted average on a programmable number of said coherent channel correction Pilot symbol accumulation over a programmable number of steps;

a channel estimator generating a channel estimation at chip rate, using outputs of said Pilot filter;

a channel corrector performing a multiplication of an incoming chip stream with a complex conjugate of said channel estimation;

a calculation of a slot energy;

Appl. No. : **Unknown**
Filed : **Herewith**

a comparison of the slot energy with a programmable threshold; and

a circuit to force said channel estimation to zero if said threshold is not exceeded.

69. (New) The communication device of Claim 68, wherein the finger is arranged for slow and fast fading compensation, by programming the channel correction Pilot filter for slow fading, said channel correction Pilot filter first performing a coherent accumulation over a slot, and secondly performing a weighted average over previous-previous, previous, actual and next obtained slot values, yielding a channel estimation per slot, which is applied by said channel corrector; and for fast fading, said channel correction Pilot filter first performing a coherent accumulation over a slot, and then deriving channel estimations through interpolating consecutive said coherent accumulations over a slot, yielding channel estimations with sub-symbol timing, which are applied by said channel corrector.

70. (New) The communication device of the Claim 59, wherein the reference demodulator comprises:

an accumulator of programmable length of the absolute values of samples at chip rate; and

a low pass filter operating on said accumulator output.

71. (New) The communication device of Claim 59, wherein the reference demodulator is arranged to operate in a runtime control loop by the processor.

72. (New) The communication device of Claim 59, wherein the demodulator is arranged to perform satellite diversity.

73. (New) The communication device of Claim 40, wherein the communication device is configured to perform accurate ranging measurements to geostationary satellites.

74. (New) An integrated circuit comprising a communication device for W-CDMA signal transmission and reception, which is software configurable, the communication device comprising:

a W-CDMA transmitter comprising at least one of a RAM and registers;

a W-CDMA receiver comprising at least one of a RAM and registers;

a signal acquisition circuit;

a digital circuit for phase unbalance precompensation comprised in said W-CDMA transmitter, said digital circuit comprising:

an input register holding a compensation angle; and

a section adapted to perform arithmetic calculations to acquire a change of an I, Q angle by the compensation angle.

75. (New) A method of operating a W-CDMA communication device comprising a W-CDMA transmitter comprising at least one of a RAM and registers, a W-CDMA receiver comprising at least one of a RAM and registers, a signal acquisition circuit, a digital circuit for phase unbalance precompensation comprised in said W-CDMA transmitter, wherein said digital circuit comprises an input register holding a compensation angle and a section adapted to perform arithmetic calculations to acquire a change of an I, Q angle by the compensation angle, the method comprising:

configuring said device for a specific use, and

performing at least one of transmitting, receiving and acquiring waveform signals.

76. (New) The method of Claim 75, wherein said waveform signals are selected from the group consisting of UMTS, Satellite UMTS, Galileo, GPS, IS-2000, IMT-2000, CDMA2000, IS-95, 3GPP, 3GPP2 and ARIB signals.

77. (New) The method of Claim 75, wherein said configuring is done by a processor.

REMARKS

The foregoing amendments are to more closely conform the application to U.S. practice. No new matter is added. Entry of the amendments is respectfully requested.

The specific changes to the specification and the claims are shown on a separate set of pages attached hereto and entitled **VERSION WITH MARKINGS TO SHOW CHANGES**

Appl. No. : **Unknown**
Filed : **Herewith**

MADE which follows the signature page of this Preliminary Amendment. On this set of pages, the insertions are underlined while the ~~deletions are struck through~~.

Respectfully submitted,

KNOBBE, MARTENS, OLSON & BEAR, LLP

Dated: 1/22/02 By: _____

John M. Carson
Registration No. 34,303
Attorney of Record
620 Newport Center Drive
Sixteenth Floor
Newport Beach, CA 92660
(619) 235-8550

H:\DOCS\MOH\MOH-6799.DOC:ad
012102

VERSION WITH MARKINGS TO SHOW CHANGES MADE

IN THE SPECIFICATION:

The heading on page 2, line 14 has been amended as follows:

~~Aims of the invention~~ Summary of Certain Inventive Aspects

The heading on page 9, line 31 has been amended as follows:

~~Short description of the drawings~~ Brief Description of the Drawings

The heading on page 40, line 1 has been amended as follows:

~~CLAIMS~~ WHAT IS CLAIMED IS:

METHOD AND APPARATUS FOR HIGH-SPEED SOFTWARE RECONFIGURABLE CODE DIVISION MULTIPLE ACCESS COMMUNICATION

Field of the invention

[0001] The present invention is related to a communication device for W-CDMA signals which is software reconfigurable. The present invention is further related to a method for operating said device.

State of the art

[0002] Some documents have already been published in the technical field of the present invention, namely:

(1) Philips et al., U.S. Patent No. 5,872,810: "Programmable Modem Apparatus for Transmitting and Receiving Digital Data, Design Method and Use Method of Said Modem", filed Jan. 26, 1996.

(2) Philips et al., U.S. Patent Application No. 08/592,700: "Programmable Modem Apparatus for Transmitting and Receiving Digital Data, Design Method and Use Method of Said Modem", continuation, filed Jan. 26, 1996.

(3) Philips et al., Patent Application EP-A-0767544: "Programmable Modem Apparatus for Transmitting and Receiving Digital Data, Design Method and Use Method of Said Modem", filed Oct. 3, 1996.

(4) Mennekens et al.,U.S. Regular patent application No. 09/306 589 "Method and apparatus for Code Division Multiple Access Communication with Increased Capacity Through Self-Noise Reduction", filed May 6, 1999.

(5) De Gaudenzi et al., U.S. Patent No. 5,327,467: "Code Distribution Multiple Access Communication System with User Voice Activated Carrier and Code Synchronization," filed May 30, 1991.

(6) De Gaudenzi et al., U.S. Patent No. 5,327,455: "Method and Device for Multiplexing Data Signals",filed July 9, 1993.

(7) R. De Gaudenzi, C. Elia and R. Viola, "Bandlimited quasi-synchronous CDMA: A novel access technique for mobile and personal communication systems," IEEE Selected Areas in Communications, vol. 10, no. 2, pp. 328-348, Feb. 1992.

Aims of the invention

[0003] The present invention aims to provide a W-CDMA apparatus which allows the implementation of various telecommunication standards, and various applications realisable according to these standards, without the need for a powerful DSP processor for the flexible part of the physical layer.

[0004] A further aim is to provide said apparatus for various fading channel circumstances.

[0005] Another aim is to provide said apparatus under the form of an Intellectual Property core.

Summary of the invention

[0006] The present invention concerns a communication device for W-CDMA signal transmission and reception, which is software configurable, comprising:

-a W-CDMA transmitter comprising RAM and/or registers;

-a W-CDMA receiver comprising RAM and/or registers; and

-signal acquisition means, characterised in that it further comprises a digital circuit for phase unbalance precompensation, said circuit comprising:

- an input register holding the compensation angle,
- means for performing arithmetic to acquire a change of the I,Q angle by the compensation angle.

[0007] According to a preferred embodiment of the present invention, said communication device further comprises a circuit for noise and interference estimation, said circuit comprising :

-means to acquire a programmable number of absolute value accumulations at chip rate or oversampled chip rate,

-a programmable low pass filter to average the noise and interference estimations.

[0008] According to a preferred embodiment of the present invention, said communication device further comprises a circuit for initial synchronization, said circuit comprising :

-a Matched Filter, energy calculation and accumulating RAM for slot synchronization,

-a set of correlators for frame synchronization & code group identification,

-an energy estimation block,

-Maximum detection means, readable by the microprocessor subsystem.

[0009] According to a preferred embodiment of the present invention, said communication device further comprises circuitry to generate packet data transmission, said circuitry comprising :

-A data and activity bits holding buffer,

-I,Q spreaders and gain control means,

-scrambling code generator and scrambling means,

-means for packet timing through RX frame edge triggering.

[0010] The present invention is equally related to the use of a communication device according to the present invention, for RACH transmission in UMTS/FDD.

[0011] Software reconfigurable means that parameters of a circuit and/or algorithmic alternatives for this circuit can be configured using software settings. The circuit itself is built up of logic, and contains memory (such as registers and/or RAM) which are preferably controlled by a processor subsystem, which performs the above mentioned software settings. Such an approach leads to lesser power consumption if compared to a complete software implementation, while there is still sufficient flexibility possible.

[0012] Said communication device can further comprise a processor. Such a processor can be any kind of processor capable of changing the settings of the device. Examples of such processors are DSP processors, microprocessors, microcontrollers, FPGA, logic circuits and FSM circuits.

[0013] The communication device is preferably characterised in that the processor is arranged to reconfigure the communication device.

[0014] Said processor preferably controls the RAM and/or registers of said W-CDMA signal transmitter and receiver.

[0015] The transmitter preferably comprises a first programmable pulse shaping filter and the receiver preferably comprises a second programmable pulse shaping filter which can be programmable to perform GMSK filtering while said transmitter and receiver are arranged to interface with a GSM front-end.

[0016] The processor can be arranged to perform the GSM protocol stack.

[0017] In a preferred embodiment, the communication device of the present invention is arranged for waveform transmission and/or reception and/or acquisition of signals selected from the group consisting of UMTS, Satellite UMTS, Galileo, GPS, IS-2000, IMT-2000, CDMA2000, IS-95, 3GPP, 3GPP2 and ARIB signals.

[0018] The transmitter of the device according to the present invention can comprise one or more elements selected from the group consisting of:

- synchronisation hardware to slave transmit start epochs to events external to the transmitter;
- a burst generator for realising discontinuous transmissions;
- a QPN channel containing one or more spreaders with their own amplification of the output;
- a combiner to accumulate the QPN channel output;
- a PN code generator;
- a scrambling code generator;
- a scrambler;
- a combiner which accumulates the scrambling code output;

a pulse shaping oversampling filter; and

- an NCO and upconverter for carrier precompensation.

[0019] The PN code generator can be realised as a RAM in which the PN codes are downloaded under control of the processor. The scrambling code generator can be realised as a programmable Gold Code generator. The QPN channel can be arranged to execute UMTS forward or return link transmission. The amplification of the spreader output is preferably arranged to perform transmit power control.

[0020] The transmitter of the device according to the present invention preferably comprises a time interpolator to perform sub-chip time alignments (e.g. for S-CDMA).

[0021] The transmitter of the device according to the present invention can be arranged for multi-code transmission.

[0022] The receiver of the communication device of the present invention can comprise:

- A pulse shaping filter;
- An optional level control block;
- A demodulator assigned to track the multi-path components received from one base station; and
- A reference demodulator for S/(N+I) measurements.

[0023] Said receiver preferably further comprises a downconverter prior to said pulse shaping filter, in order to interface at a front-end at an intermediate frequency. It can also be arranged for execution of UMTS, Satellite UMTS, Galileo, GPS, IS-2000, IMT-2000, CDMA2000, IS-95, 3GPP, 3GPP2 and/or ARIB forward link and return link waveforms.

[0024] The level control block preferably comprises:

- a programmable shifter to perform coarse grain dynamic control;
- a programmable multiplier to perform fine grain dynamic control;
- an overflow counter operating on the most significant and the second most significant bit;
- an overflow counter operating on the second most and the third most significant bit; and
- saturation logic to clip the result from the multiplier;

[0025] The level control block is preferably operated in a runtime control loop by the processor.

[0026] The demodulator preferably comprises:

- a Rake filter, producing a signal at chip rate which is a coherent accumulation of channel corrected multipath components resulting from one base station;

- a tracking unit, using said signal at chip rate for descrambling and despreading a plurality of waveform channels;

in which said Rake filter comprises:

- a FIFO to buffer samples at chip rate, coming from said level control block;
- a delay line containing a plurality of registers, the input of the delay line being connected to the output of said FIFO;
- a plurality of finger blocks, the inputs of said finger blocks being connected to programmable tap positions on said delay line; and
- a summator of complex outputs of said finger blocks at chip rate.

[0027] The finger blocks are preferably respectively grouped in a late multipath group and an early multipath group, the Rake filter being arranged to accumulate the energies of the outputs of said late multipath group and said early multipath group, and to use these accumulated values to feed the time error detector of the DLL used for time tracking.

[0028] The Rake filter can comprise memories to hold one or more of the following:

- spreading code for a channel correction Pilot;
- scrambling code for a channel correction Pilot;
- a channel correction Pilot symbol modulation;
- a channel correction Pilot symbol activities.

[0029] Said memories are preferably controlled by the processor.

[0030] The finger block preferably comprises:

- a channel correction Pilot descrambler;
- a channel correction Pilot despreader;

- a channel correction Pilot filter, first performing a coherent channel correction Pilot symbol accumulation over a programmable number of steps, and secondly producing a weighted average on a programmable number of said coherent channel correction Pilot symbol accumulation over a programmable number of steps.
- a channel estimator, generating a channel estimation at chip rate, using the outputs of said Pilot filter;
- a channel corrector, performing a multiplication of the incoming chip stream with the complex conjugate of said channel estimation;
- a calculation of the slot energy;
- a comparison of the slot energy with a programmable threshold;
- a circuit to force said channel estimation to zero if said threshold is not exceeded.

[0031] The finger can be arranged for slow and fast fading compensation, by programming the channel correction Pilot filter for slow fading, said channel correction Pilot filter first performing a coherent accumulation over a slot, and secondly performing a weighted average over previous-previous, previous, actual and next obtained slot values, yielding a channel estimation per slot, which is applied by said channel corrector; and for fast fading, said channel correction Pilot filter first performing a coherent accumulation over a slot, and then deriving channel estimations through interpolating consecutive said coherent accumulations over a slot, yielding channel estimations with sub-symbol timing, which are applied by said channel corrector.

[0032] The reference demodulator preferably comprises:

- an accumulator of programmable length of the absolute values of samples at chip rate; and
- a low pass filter operating on said accumulator output.

[0033] The reference demodulator can be arranged to operate in a runtime control loop by the processor.

[0034] The demodulator is preferably arranged to perform satellite diversity.

[0035] The communication device of the present invention can be arranged to perform accurate ranging measurements to geostationary satellites.

[0036] A further aspect of the present invention is an Integrated Circuit comprising the communication device of the present invention.

[0037] A further aspect of the present invention is an Intellectual Property core comprising the communication device of the present invention (as a building block for inclusion in an integrated circuit).

[0038] Another aspect of the present invention is a method for operating a W-CDMA communication device of the present invention, characterised in that it comprises the following steps:

- configuring said device for a specific use, and
- transmitting and/or receiving and/or acquiring waveform signals.

[0039] Said waveform signals are preferably selected from the group consisting of UMTS, Satellite UMTS, Galileo, GPS, IS-2000, IMT-2000, CDMA2000, IS-95, 3GPP, 3GPP2 and ARIB signals. Said configuring is preferably done by a processor.

Short description of the drawings

[0040] Fig. 1 represents the global transmitter structure for the device of the present invention.

[0041] Fig. 2 represents à QPN channel.

[0042] Fig. 3 represents the use of a RAM block to generate PN-codes.

[0043] Fig. 4 to 7 represent some possible RAM configurations for the device of the present invention.

[0044] Fig. 8 illustrates the phase unbalance compensation.

[0045] Fig. 9 represents a receiver architecture for the device of the present invention.

[0046] Fig. 10, 11, 12 and 13 represent respectively a level control, a noise estimator, a general overview of a demodulator and a tracking unit usable in a device according to the present invention.

[0047] Fig. 14 represents a possible configuration of a demodulator for UMTS mode, using only 1 tracking unit.

[0048] Fig. 15 and 16 represent respectively a Rake Receiver and a Rake Finger according to the present invention.

[0049] Fig. 17 represents slotwise coherent pilot symbol accumulation according to the present invention.

[0050] Fig. 18 represents finger energy calculation.

[0051] Fig. 19 represents a slot weighing filter for the device according to the present invention.

[0052] Fig. 20 shows an overview of the Rake finger process in the case of Channel Mode 0.

[0053] Fig. 21 and 22 draw an overview of the Rake finger process in the case of Channel Mode 1.

[0054] Fig. 23 illustrates the noise estimator.

[0055] Fig. 24 represents the noise estimator's functional structure.

[0056] Fig. 25 illustrates the SCH RX hardware.

[0057] Fig. 26 represents the slot synchronization.

[0058] Fig. 27 represents the PRACH TX hardware.

Detailed description of the invention

Abbreviations

BCCH	Broadcast Control Channel
BS	Base station
CCPCH	Common Control Physical Channel
DL	Downlink
DPCH	Dedicated Physical Channel
DPCCH	Dedicated Physical Control Channel
DPDCH	Dedicated Physical Data Channel
HO	HandOver
LPF	Low Pass Filter
MRC	Maximum Ratio Combining
MS	Mobile station
NC	Number of Chips
OVSF	Orthogonal Variable Spreading Factor
PN	Pseudo-Noise
PRACH	Physical Random Access Channel
QPN	Quadrature Pseudo-Noise
RSSI	Received Signal Strength Indication
SCH	Synchronization channel
SF	Spreading factor
SRRC	Square Rooted Raised Cosine
UL	Uplink
W-CDMA	Wide Band CDMA

Transmitter Specification

[0059] The global transmitter structure 1 is shown in Fig. 1. It is explained in detail in the next sections.

QPN channels with synchronisation hardware and PN-code generators

[0060] The transmitter contains a plurality of QPN channels 3 (Fig. 2). These channels are e.g. combined in

two sets of four QPN channels (set A and set B) and set C with only one QPN channel, as can be seen in Fig. 1.

[0061] Each set has a separate block for generating the PN-code 5 and separate synchronisation hardware 7 which defines the start of symbol transmission.

Synchronisation hardware

[0062] The output of this part goes to the QPN channels of a set and defines a common symbol start moment for all QPN channels in a set. This signal is generated as a selection of 1 out of a plurality of incoming signals with a programmable offset.

[0063] The incoming sync channels can e.g. be generated by : another chip, TX timers, receiver pulse, acquisition hardware output,...

[0064] To generate the offset a counter at chip rate can be used. This gives an offset resolution of 1 'primary' chip. The range of the offset is [0:65535]. This is sufficient to give an offset of 1 frame for UMTS (40960 chips).

QPN channel

[0065] Each QPN channel 3 has the functional structure represented in Fig. 2. Its functional elements are described below:

Spreader 11

[0066] The input binary symbols, coming directly from the interface (symbI 13 and symbQ 14) are spread with the PNbits PNbitI and PNbitQ. Each symbol has an activity bit (actI and actQ). When this is 0 the functional spreader output will be 0 in stead of +1 or -1.

[0067] This activity bit is used for burst transmission and for BPSK in stead of QPSK/QPN transmission.

[0068] symbI and actI are signals at symbolrate fsIxx, symbQ and actQ are signals at symbolrate fsQxx. fsIxx can differ from fsQxx. The spreading factor is set by the sfI 15 and sfQ 16 inputs.

[0069] The spreaders can be (re)started via the sync signal 17.

fcp=fsIxx * sfI = fsQxx * sfQ.

[0070] Symbol clock signals 19 (symbclkI and symbclkQ) are generated as a symbol reference for other hardware that requires symbol synchronous actions, like the gain controls 21.

Gain Control (Transmit power control)

[0071] Each complex spreader 11 is followed by a separate gain control 21. Each output branch of a spreader is again separately gain controlled.

PN-code generators

[0072] These blocks generate the complex PN codes for the QPN channels 3 (fig. 1). A code generator 5 is foreseen per set. An example: the PN-code generators 5 for set A and B generate each 4 complex codes, while the generator 6 for set C generates only 1 one complex PN-code.

Gold code generator

[0073] This is a classical Gold code generator with e.g. 42 bit registers which can generate any Gold code with any length up to (2^42)-1. It can also be used to generate any segment out of a Gold code smaller than (2^42)-1.

[0074] The sgfb inputs define the feedback position in the shift register, the init inputs are used to

initialise the shift registers at reset or restart. The poly inputs are used to program the polynomials to generate the Gold sequences. The rest signals are used to make generate a small section of the complete Gold code and then jump to the back to the init value. If the register in the gold code generator reaches the rest state, the register is in the following clock-cycle re-initialised.

RAM based code generation

[0075] Each set has a block 23 which can generate PN-codes based on a RAM. For all three sets the same block 23 is used. This is shown in Fig. 3.

[0076] The block 23 contains a RAM of e.g. 8*1024 bits. An address generator selects one row 35 of this RAM with the x address, then these 8 bit are routed to the spreaders via a switch controlled by address y.

[0077] The address generator 31 has a start 25, stop 27 and step input 29. The address generator can be configured in different ways with the configure input 33.

[0078] It is possible to stop the generators when the activity bit of a symbol is 0.

[0079] Below a number of illustrated examples of possible RAM configurations are given:

-Fig 4: 8 BPSK streams 37, stream 0,1,4,5,6 and 7 have SF 1024, stream 2 has SF 512 and stream 3 has SF 256; x counts from 1023 to 0, y is a static value.

-Fig 5: 6 BPSK streams 37, stream 0 and 5 have SF 2048, stream 1 has SF 512, stream 2 has SF 256, streams 3 and 4 have SF 1024; x counts from 1023 to 0, y changes between 2 values every 1024 chips.

-Fig 6: 2 BPSK streams 37, stream 0 and 1 have SF 256, stream 0 uses continuously the same code. while stream 1 uses a sequence of 16 different codes. This scheme is

usable for SCH transmission if the addresscounter is stopped when the activity bit is 0. x counts from 1023 to 0, y changes between 4 values every 1024 chips.

-Fig 7: 4 BPSK streams 37, stream 0 has SF 1000, stream 1 has SF 2000, stream 2 has SF 400, stream 3 has SF 600; x counts from 999 to 0, y changes between 3 values every 1024 chips.

[0080] As shown in these examples, in the case of variable spreading factor transmission (e.g. OVSF codes in UMTS), it is assumed that spreading factors have a common multiple. The RAM is filled with replica's until the common multiple length is reached. In this way the symbols in one set are multiple-symbol synchronous.

Combiners at fcp rate

[0081] The two combiners 38 after set A and set B at fcp rate output the sum of the 4 incoming complex numbers.

Scrambler 40 and scrambling code generation

Scrambling code generator 41

[0082] This block generates the complex scrambling code Cscramb = cI+jcQ.

[0083] Each scrambling code generator has its own synchronisation hardware block to generate the sync signal. (see Fig. 1).

[0084] The scrambling code generator contains 2 Gold code generators with 42 bit register, 2 RAMs of 256 bit, an interface for external input of codes and some extra hardware for UMTS to modify the Gold codes.

[0085] The Gold code generators are functionally the same as the Gold code generators in the PN code generators.

[0086] This is a classical Gold code generator with 42 bit registers which can generate any Gold code with any

length up to (2^42)-1. It can also be used to generate any segment out of a Gold code smaller than (2^42)-1.

[0087] The sgfb inputs define the feedback position in the shift register, the init inputs are used to initialise the shift registers at reset or restart. The poly inputs are used to program the polynomials to generate the Gold sequences. The rest signals are used to make generate a small section of the complete Gold code and then jump to the back to the init value. If the register in the Gold code generator reaches the rest state, the register is in the following clock-cycle re-initialised.

[0088] It is possible to re-initialize the generators after a programmable number of chips or to let them run freely.

Examples of different modes

Mode 0

[0089] cI and cQ are any Gold code with any length of maximum (2^42)-1.

Mode 1

[0090] cI and cQ come directly from a RAM of 256 bit. it must be possible to use only the first k bits in the RAM, with k smaller than 257.

Mode 2

[0091] Mode0 but with zero extension in front of the generated Gold codes. cI = <0,c1>, cQ = <0,c2>

Mode 3 (UMTS specific)

[0092] Mode0 or Mode1 but c1 and c2 coming from the Gold code generators or RAM are modified in the following way:

Cscramb = cI+jcQ = c(w + jc'w)

where w0 and w1 are chip rate sequences defined as repetitions of:

w = {1 1}

w = {1 -1}

and where c is a real chip rate code, and c' is a decimated version of the real chip rate code. The preferred decimation factor is 2, however other decimation factors should be possible in future evolutions of UMTS if proven desirable.

[0093] With a decimation factor of decim=2, c' is given as:

c'(2k)=c'(2k+1)=c(2k), k=0,1,2...

[0094] c1 and c2 are constructed as the position wise modulo 2 sum of 40960 chip segment of two binary m-sequences generated by means of two generator polynomials of degree 41.

[0095] The code c2, used in generating the quadrature component of the complex spreading code is a 1024-chip shifted version of the code c1 used in generating the in phase component.

Scrambler 40

[0096] The scrambling is in fact an overlay spreading without changing the chiprate, the change in chip rate is done with the Hold 1-256 block.

Input data : dI+jdQ

Input scrambling code : cI+jcQ

[0097] This block has 3 modes:

-Off : output = input

-Complex scrambling : output = (dI+jdQ)*(cI+jcQ) = dI*cI-dQ*cQ + j(dI*cQ+dQ*cI)

-Dual real scrambling : output = dI*cI + j dQ*cQ

Interpolator with chip phase control

[0098] This block is used to do a chip phase shift with a resolution smaller than 1 chip. For every sample in, one output sample is generated, input and output clock is the equidistant clock.

[0099] A linear interpolation is used to perform this function:

out(k) = (1-TXMU)*in(k-1)+TXMU*in(k)

where in(k-1) and in(k) are 2 consecutive equidistant complex samples at rate; TXMU is an input of the block and is an number (0<= TX_MU<=1).

Upsampling and programmable filter

[0100] The fixed upsampling with a factor of e.g. 4 (zero insertion) and a symmetrical programmable filter are realised as a complex oversampling polyphase filter. The output sampling rate f4c = 4 * fc.

Offset modulation

[0101] By setting offset to 1, the Q branch will be delayed with 0.5 chip.

Complex upconvertor 42 and NCO 44

NCO 44

[0102] This block generates a cosine and sine value. The cos and sin values are frequency and phase controlable.

[0103] The specifications below are not required for cellular, but can be used for satellite applications with demanding phase noise requirements.

[0104] The sine and cosine values are generated with the 16 MSB of a s<32,0> phase value. The 14 LSB of this 16 bit number go to 2 lookup tables which contain the values for sin and cos in [0,2*pi[with a gain of 2047/2048. The lookup wordlength for sin and cos in

quadrant 1 is u<11,11>. The 2 MSB of the s<32,0> bit phase register are used to recover the quadrant, sin and cos are s<12,11> numbers. The output of the NCO is the complex signal (cos + j.sin).

[0105] The s<32,0> bit phase register can be directly controlled via the TXPHASE input (s<32,0>) or by integrating with wrap around the TXINC (s<32,0>) value. The TXINC can be used to program the frequency of the generated sine and cosine in the following way:

fsin = fcos = TX_INC/2^32 * f4c.

[0106] With TXINC negative a negative (complex) IF will be generated.

[0107] For example, to generate a complex carrier at -20 MHz with, TXINC should be set to -1073741824.

[0108] The s<32,0> phase register should be a part of the chip boot chain.

Upconverter 42

[0109] Here a complex upconversion with the NCO generated complex carrier is done.

[0110] The computations are done full precision, the multiplications have 1 redundant bit as the most negative number will never be present in the sin or cos value. Thus the result of the multiplications are s<32,24> bit numbers. This makes the full precision outputs bit numbers.

[0111] These full precision numbers are reduced to s<35,16> numbers.

Level Control 2

[0112] The purpose of this block is to condition the signal coming from the upconverter prior to the DA conversion.

Phase unbalance compensation (Fig. 8)

[0113] Digital phase unbalance compensation is used to remove the I,Q phase difference from 90 degrees prior to A/D conversion.

A phase unbalance compensation is done :

$$Iout = Iin + Qin * \tan(ß)$$
$$Qout = Qin + Iin * \tan(ß)$$

with 2ß the phase angle to correct.

tan(ß) is stored in the TGCR_AC variable. A range for 2ß is larger than 13 degrees. The resolution of 2ß is smaller than 1 degree.

The transfer of TGCR_AC is synchronous with the I0A symbol clock.

Receiver Specification

[0114] The global receiver structure is shown in Fig 9. All functional blocks are discussed in more detail in the next paragraphs.

Common downconverter with NCO 47

Downconverter 45

[0115] This block performs a complex downconversion, with the NCO generated complex carrier, on the incoming complex signal. The output signal is expected to be a near baseband signal.

DO_MODE	data in	carrier in	output
00	X+jY	cos+jsin	(X+jY)*(cos+jsin)
01	X+jY	cos+jsin	(X+jY)*(cos-jsin)
10	X+jY	cos+jsin	X*(cos+jsin)
11	X+jY	cos+jsin	X*(cos-jsin)

[0116] Input and output are at fin rate.

Programmable FIR filter 49 with downsampling 51

[0117] The complex receive stream coming from the downconverter is filtered by a programmable symmetrical FIR filter and downsampled with a factor RXD. RXD can be 1 or 2.

[0118] Inputs are at fin rate, outputs at f2ct rate.

Level control 53 with overflow detectors

[0119] To optimise the number of significant bits going into the demodulator correlators a common level control is foreseen to adapt the level of the signal coming from the filter (see Fig. 10 for the structure).

[0120] The incoming complex data is shifted over a RXSHIFT bits 55. This is a coarse gain with 6 dB steps. A lower resolution gain control is done by the multiplication by RXMULT 57. The multiplication is followed by saturation logic (on the data) abd overflow counters. For this reason the result from the multiplication is extended with 1 MSB to produce the input for overflow counter 1. Overflow counter 1 59 counts the real overflows, so the overflows where the saturation logic saturates the signal. Overflow counter 2 61 is required to count the overflows as if the signal amplitude was twice as big.

S/(N+I) estimator (63)

[0121] The noise estimator 63 (Fig. 11) provides a filtered complex noise correlation value which can be read by the microcontroller subsystem. This value could be used for setting thresholds in the acquisition hardware. The noise correlator 65 is just the accumulation of NC_lenght absolute values 64 of the complex input. In this way, an RSSI estimation is obtained.

[0122] The filter is a simple hardware low-pass filter.

[0123] By setting bypass to 1, the low-pass filter can be bypassed.

Demodulator 67

[0124] In most modes the plurality of demodulators are used to support base station diversity for soft hand-over, however they can also be used for other purposes. In the following paragraphs the demodulator structure will be explained in more detail.

[0125] Figure 12 gives a general overview of a demodulator 67. It consists of a number of tracking units 69 with their peripheral hardware like code generators and feedback signal generators like PED with PLL 70, TED with DLL 97, AED 91 with AGC 93. This will be discussed in more detail further.

[0126] Each demodulator also has a Rake block 71 performing a combination of channel corrected multipath components. This block will also be discussed in more detail later.

[0127] Not all the hardware in Fig. 12 is used at the same time. This depends on the configuration. It is possible to turn off idle blocks to save power.

Tracking unit 69

[0128] Each of the e.g. 3 tracking units 69 (Fig. 13) has the same input: the complex signal coming from the common level control. It is possible to track one signal source with one tracking unit. A signal source can be a physical transmitter or it can be a multi-path component coming from one transmitter. So in one demodulator we can e.g. track 3 satellites or track 3 multi-path components (as an alternative to the use of the above mentioned Rake) from a terrestrial base-station. The functional blocks within a tracking unit are described below.

Tracking unit downconverter 45 and NCO 47

[0129] This block is used as actuator for the carrier phase/frequency tracking. A final downconversion is performed.

Tracking unit interpolator 74 with chip frequency control

[0130] This block is used as actuator for the chip phase/frequency tracking. This is done by a pseudo-chip rate change. The outcoming chip rate is controlled via the DINT input.

[0131] Linear interpolation between samples spaced approximately 0.5 chip is performed by:

out(k) = (1-INTMU)*in(k-1)+INTMU*in(k)

where in(k-1) and in(k) are 2 consecutive equidistant samples at f2c rate.

[0132] The DINT input is used to change the INTMU continuously by adding DINT to the previous value of INTMU every cycle. This results in a change in chiprate by 1/(1+DINT).

-INTMU in [0:1[: one input sample produces 1 output sample

-when INTMU 0 : two output samples are produced for one input sample, and INTMU is wrapped back into [0:1[

-when INTMU >= 1 : no output sample is produced for one input sample and INTMU is wrapped back into [0:1[

[0133] This block causes a delay of 1 sample. For example, when DINT = cte = 0, out = in z^-1 with a 0.0 added at the start.

[0134] The input samples are equidistant at f2c rate. The output samples of the interpolator are not equidistant at f2cr rate. f2cr is between f2c/2 and 2*f2c. So all the hardware after the interpolator must be designed to work at 2*f2c although its nominal rate will be f2c.

MEL gate 75

[0135] This MEL gate 75 is only used in no-cellular modes; otherwise it's bypassed through the appropriate multiplexer settings. The incoming stream at f2cr is split in three streams at f2cr rate.

E = in.z^-2

M = in.z^-1

L = in

[0136] In this way each stream is spaced 0.5 chip.

[0137] The M signal of Tracking unit 0 is also used as input for the Rake block, if it is activated (see further).

Downsampling 80 factor

[0138] A phase controllable downsampling with a factor e.g. 2 is performed here by skipping 1 incoming sample of 2 incoming samples. D2 defines which phase to skip. The output rate is fc = f2cr/2.

Chip stream selection

[0139] The 3 multiplexers 81 allow to choose between which signal goes to the final correlators 83. This can be the downsampled signal coming from the MEL gate or it can be the Rake output at chip rate.

Scrambling code generator 41

[0140] This is functionally the same as the transmitter scrambling code generator, but at fc rate.

Descrambler 83

Input data : dI+jdQ

Input scrambling code : cI+jcQ

[0141] This block should have 3 modes :

-Off : output = input

-Complex descrambling : output = (dI+jdQ)/(cI+jcQ) = (dI.cI+dQ.cQ + j(-dI.cQ+dQ.cI))/2.0

-Dual real scrambling : output = dI*cI + j dQ*cQ

[0142] In the 3 modes the delay between in and output should be the same. Input and output are at fc rate.

Despreaders 85

[0143] Each tracking unit contains a number of QPN despreaders. Each despreader and each branch of the despreader can have a different spreading factor.

Variable amplifiers 87

[0144] This block is used as actuator for the signal amplitude tracking. Each Vamp 87 can have a different gain.

[0145] The output of the Vamps are the soft symbols MD, MP, EP and LP which stands for Middle Data, Middle Pilot, Early Pilot and Late Pilot but when in Rake (UMTS

mode) these signals have completely different meanings than these names suggest.

PN-code generators 89

[0146] This block generates the complex PN-codes for the despreaders 85. This is a similar block as in the transmitter. So possibility to use a RAM, Gold code generator or an external input.

[0147] Tracking unit 0 is equipped with e.g. 4 separate generators, unit 1 and 2 have only 1 generator. So the 4 despreaders in unit 1 and 2 use the same despreading code.

AED 91 and AGC 93

[0148] The AED 91 is the error detector for the signal amplitude tracking. The AGC 93 does a filtering on this signal and outputs the signal going to the Variable amplifiers.

[0149] Tracking unit 0 has 4 separate AED and AGC for each despreader in the tracking unit, while tracking unit 1 and 2 only have a common AED and AGC working on the MP signal.

PLL 70

[0150] The NCO of each tracking unit can be set by an external block like ARM software or can be controlled by the PLL. The PLL works on the MP signal. When the Rake is used, the PLL is turned off.

TED0, TED1 and DLL 97

[0151] The TED0 or TED1 are used as error detectors for the chip timing tracking. TED1 is used when the CCP is used as a signal source for the despreaders of the unit, while TED0 is used when classic Early-Late correlator

tracking is done. The output of the TED 91 goes to the DLLs, chip frequency controling the interpolator.

Symbol combiner (not shown)

[0152] When the 3 tracking units are used for tracking different multipaths of the same signal, a hardware combination of the 3 CD outputs can be performed. Functionally this is only an addition of the complex CD numbers. However the symbol timing of CD[0], CD[1] and CD[2] will be different which will complicate the coherent symbol combining.

Rake receiver 101

[0153] This block (Fig. 15) performs a weighted coherent combination of a plurality of taps selected on a delay line of the chip stream, resulting into one new chip stream. To combine them weighted coherently a channel estimation (amplitude, phase) of each of the delayed chip streams is made. This block is discussed in detail further.

Demodulator using Rake

[0154] This section gives a detailed explanation on the use of the demodulator as a receiver where multipath components are coherently combined at chiprate. The Rake block of the demodulator is only used in this mode and is also discussed in detail in this section.

[0155] This specification is e.g. for reception of a UMTS waveform.

[0156] A possible configuration of a demodulator for UMTS mode, using only 1 tracking unit 90, is shown in Fig. 14.

[0157] The Rake-based demodulator configuration reuses almost everything from the tracking unit except for the PLL and PED. A large extra block that is not used when

using Early-Late correlator tracking is the Rake 71. So roughly said the Rake-based demodulator consists of the Rake that generates a new chip stream from the incoming chip stream and the classic descrambler 83, despreader 85,... hardware.

[0158] With the configuration of Fig. 14 it is possible to receive 4 QPN channels. These channels must be synchronous as they use the same Rake receiver. These 4 QPN channels must also have the same scrambling code. With tracking unit 1 and 2 with Rake as input (not on figure) we could receive 2 extra QPN channels with a different scrambling code. They must still be synchronous with the other channels. To receive two asynchronous transmitters one must use the 2 demodulators.

[0159] The only despreading in the Rake is the pilot symbol despreading used to make the channel estimations.

[0160] Chip phase tracking is done by a timing error detector (TED0) and DLL working at slotrate.

[0161] More details can be found further.

Rake overview

[0162] This part (Fig. 15) performs the coherent combination of a plurality chip streams 107 into one new chip stream 109. We have e.g. 8 fingers 111, where a channel estimation is done for that chip phase with the aid of pilot symbols. This channel estimation is used to 'correct' the chip stream of the respective finger, after which all fingers can be combined. MRC with optional zero forcing is used to combine the different chip phases.

[0163] The pilot symbols can have a SF from 4 to 256 and may be arbitrarily distributed over the slot.

[0164] Fingers 0 to 4 contribute to the Late multipaths, fingers 5 to 7 to the Early multipaths. Note that there is no real 'Middle' finger, this means that in

the case of a single path, the correlation energy will be split over finger 4 and 5 and one will never correlate at the 'top' of the correlation shape.

[0165] In one of the possible ways of using the Rake, it will be initialised so that the strongest peak will be between finger 4 and 5. With the phase controllable decimation (D2) the chip phase can be set with a resolution of 1/2 chip.

[0166] Each finger has as inputs:

-Pcb : the codebit for despreading the pilot chipstream. The spreading code is stored in a RAM of 256 bits. This is a real signal, no QPN pilot is possible.

-Psb : the complex descrambling bits coming from the descrambling code generator.

-Psy : the data modulation on the pilot symbols. One can use a RAM to store the modulation of a complete slot, so one needs a RAM of 640x2 bits. When a higher SF is used not all 640 locations will be used. Eg with SF 256 only the first 10 locations of the RAM will be used. Pilot modulation can change on a slot to slot basis.

-Pac : activity bit for pilot symbols. This eliminates the need for having the pilot portion as a continuous portion at the beginning of the slot. Again a RAM of 640x1 could be used.

-Psf : The pilot SF.

-Chm : channel mode parameter, selects the algorithm to use to make the channel estimations. (slow fading : 0, fast fading 1).

[0167] Other configuration inputs like: threshold to decide on which finger there is a signal, filter coefficients for channel estimation filtering, etc. They are not on Fig. 15 as they are too detailed for this drawing.

NOTE : the RAMs of 640 bits could be smaller if it is not required that we could have a burst of pilot chips equal to 4 chips anywhere in the slot. It is most likely that this is not required. E.g. 8 consecutive pilot symbols SF can be replaced by 1 pilot symbol with SF 32.

[0168] Each finger has a complex CCCP[x] output at chip rate. This is the delayed chips multiplied with the complex conjugate of the channel estimation of finger x.

[0169] Each finger also has a FNx output at slot rate which is the energy of the coherent accumulation of all pilot chips/symbols in a slot of finger x.

[0170] The sum of all FNx is calculated and goes to the pilot AGC. In this way CCCP will not be dependent on the pilot energy.

[0171] As one has fixed finger spacing we only need a global DLL.

[0172] The DLL will work on slot rate, the Late and Early energies are calculated as:

ENL = FN0+FN1+FN2+FN3+FN4,

ENE = FN5+FN6+FN7.

[0173] ENL and ENE go to the DLL which feedbacks to the interpolator at the input of the demodulator using the Rake filter..

Rake finger 115

[0174] This section describes the fingers architecture (see Fig. 16).

Descrambler 117

[0175] The incoming chips are descrambled with Psb. This code and its phase is common for all fingers. The phase has to be set during an acquisition process initialising the Rake. Has the same functionality as the other descramblers.

Complex pilot despreader 119

[0176] The complex signal coming from the descrambler at chip rate is despread with the pilot PNcode (Pcb), only 1 despreader, so the pilot must be a QPSK or BPSK signal.

[0177] The pilot PNcode has a PNlength of Psf. 4<=Psf<=256, and k*Psf=2560 with k a positive integer.

[0178] The despreader works continuously and is synchronised to the slot edge at chip rate. This means that a new symbol starts at the start of the slot (slot-edge=1).

Variable Amplifier 121

[0179] The complex symbol coming from the despreader is sent through the Variable Amplifier (VAMP) 121. The complete CCMR has one global AGC which sets the Pgain at slotrate.

[0180] For different spreading factors, the initial gain must be set to a different value, eg to 1.0 for SF 256, to 64.0 for SF 4.

Pilot filter 123. Slotwise coherent pilot symbol accumulation 124

[0181] In this block a coherent pilot symbol accumulation is done on a slot by slot basis. The Pac input defines if the symbol coming from the VAMP is a pilot symbol. See Fig. 17.

[0182] In this example the Psf is 256, Pac would be 111100000....0000.

[0183] Pi with i=0,1,2,… the pilot symbol index, are the complex despread pilot symbols Dva (@fsymbB). In order to accumulate them coherently, the pilot modulation must be removed first. This modulation is known a priori and must

be present at the Psy input. For QPSK Psy can take 4 values : +1, -j, +j, -1.

[0184] For QPN Psy can take 2 values : +1 and -1. So Psy is represented by a 2 bit value (Psy[0] and Psy[1]).

[0185] The values Pi are then demodulated in the following way (Piu are the demodulated values of Pi)(u= unmodulated):

Psy[0..1]	Pi	Piu
00	Pii + j * Piq	Pii + j * Piq
01	Pii + j * Piq	-Piq + j * Pii
10	Pii + j * Piq	Piq - j * Pii
11	Pii + j * Piq	-Pii - j * Piq

[0186] For QPN Psy must only take the values 00 or 11.

[0187] Spj are the complex accumulation of these demodulated pilot symbols from the current slot, divided by the number of pilots (or multiplied by 1/number of pilot symbols):

Sp = accumulation of Piu, divided by the number of Pilot symbols.

[0188] This is equivalent with despreading over all the pilot chips in the slot in the case of unmodulated Pilot symbols.

[0189] Sp values are generated at slot rate fslot. The value is available at the end of the slot.

[0190] This module is slot-synchronous.

Finger energy calculation 125

[0191] Here a measure for the finger energy is calculated slot by slot. Because there is a delay of 2 slots on the chips we would also calculate the energy from a delayed Sp value. This is shown in Fig. 18.

[0192] The energy is calculated as follows: Sp_i^2+Sq_q^2. With a delay of 1 slot on Sp.

[0193] This energy will be used for the DLL and zero forcing.

Channel estimator 127

[0194] This block performs a filtering or interpolation on the Sp values.

[0195] The exact function to perform depends on the Chm (channel mode) input (fast or slow fading channels).

[0196] The output of this block is the channel estimation ces at chiprate.

[0197] When Chm = 0, the Ce_FIRcoef[4] and Ce_FIRmult[4] inputs are needed, when Chm = 1 the pipo input is needed.

Channel mode 0: Slow fading 131

[0198] In this mode ces is constant over a complete slot. ces is a filtered version of the incoming Sp values. See Fig. 19.

[0199] The multiplication after the filter is to have a FIR filter 129 with unity gain. To avoid a transient in the amplitude on the signal coming from the filter, 4 different values are stored for this gain. The first output of the filter gets gain CeFIRmult[0], the second output CeFIRmult[1], the third CeFIRmult[2] and CeFIRmult[3] is used on sample number 4 leaving the filter and in steady state mode.

[0200] All filter taps should be initialised to 0 at the start of the process.

[0201] The filter and multiplier work at slotrate fslot, ces are samples at chiprate. (oversampling of filter output). Fig. 20 gives an overview of the Rake finger process 131 in the case of channel mode 0.

[0202] The different pilot symbols are demodulated and coherently accumulated giving the values Sp0 to Sp5. The channel estimations ces are the output of the 4 taps FIR filter, ces0 is a function of Sp0 to Sp3. ces0 is constant over slot number 4. The De chip from slot 2 is delayed 2 slots so that it is available with slot 4 as Dl chip. This chip is multiplied with the complex conjugate of ces0 to give the Dro chip of this finger.

[0203] It is clear that the chip arriving in slot 2 is 'corrected' with the info from pilot symbols of slot 0,1,2 and 3.

[0204] Every chip is always corrected with the aid of the Before Before, Before, Present and After slot. (unless some filter taps are set to 0). Channel estimations change only at slot rate. Note that Sp3 is generated together with the last chip of slot 3 while ces0 which is a function of Sp3 is used for all chips of slot 4.

Channel mode 1: Fast fading 133 and 135

[0205] In this mode ces are interpolated values between the current and the previous Sp values entering the channel estimator. So ces changes at chip rate. See Fig. 21.

[0206] The incoming Sp values are positioned in the middle of the pilot portion to calculate the other complex values. The pipo (pilot position) input is used for this. It is an integer in the range [0:2559]. In Fig. 22, pipo would be 768 or 769 (3/5*2560/2).

[0207] Linear interpolation is performed on both real and imaginary part of the Sp values. In this way we go via a straight line in the complex plane from Sp(k-1) to Sp(k).

Re[ces(i)]=(Re[Sp(k)]-Re[Sp(k-1)])*(i-pi_po)/2560+Re[Sp(k-1)]

Im[ces(i)]=(Im[Sp(k)]-Im[Sp(k-1)])*(i-pi_po)/2560+Im[Sp(k-1)]

with i=0,1,2,...2559 The 2560 different chips in a slot.

[0208] See Fig. 22 for an overview of the Rake finger process 135 in case of channel mode 1.

[0209] The different pilot symbols are demodulated and coherently accumulated giving the values Sp0 to Sp5. The channel estimations ces(i)for the chips i of slot 2 are calculated during slot 4 with the aid of Sp2 and Sp3.

[0210] So the Present and Future slot is used to make the channel estimates.

Channel correction 128 (fig 16)

[0211] This block has as input the delayed chips Dl coming from the FIFO and the channel estimations per chip ces.

[0212] The function of this block is to correct for the channel phase of the finger and give a weight to the finger. The outputs from the different fingers can then be combined (coherently) in one signal.

[0213] The following action is performed in these blocks:

Dro = Dl*ces(*) with ces(*) the complex conjugates of ces.

Zero forcing 126 (fig 16)

[0214] Each finger output can be forced to zero with the zf signal.

[0215] The purpose of this is to set a finger to 0 when no (or very little) signal is present in that finger to avoid the accumulation of a lot of noise.

[0216] The zf signal is obtained by comparing the slotwise FN and a programmable threshold. zf is 1 if FN <= threshold.

Noise estimator (Fig. 23)

[0217] The purpose of this block is to get an estimate of the noise power before the despreaders.

The block is present on despreaders 0 of tracking unit R input, so at the output of the descrambler.

[0218] The N estimator calculates :

$$\sum_{i=0}^{RR.NC.LEN.}(c_i^2 + c_q^2)$$

with c_i, c_q the real and complex input of the despreader. The noise power is then the ouput of this block divided by RR._NC_LEN.+1.

The functional structure is shown in figure 24.

[0216] Then these numbers are filtered by a low-pass filter :

filter_out = (1-α)*filter_in + α*filter_out*z^{-1}

By setting alpha to 0, the filter is bypassed.

RR_NC_ALPHA is a <6,6> number.

[0219] The output of the filter goes to the register RR_NC_OUT.

With the start signal the integration can be restarted at any moment.

SCH RX hardware (Fig. 25)

[0220] 3 modes are possible : initial cell search, idle mode cell search and active mode cell search.

Initial cell search

Steps 1 and 2 of the Initial Cell Search are discussed here:

Step 1 : Slot synchronisation (fig. 26)

[0221] In this step, the MS acquires slot synchronisation by doing a fast acquisition on Cp which is common to all Bss.

The samples coming from the SRRC filter and at 2 fchip are sent through a matched filter 200 with the Cp code.

The first 5120 moduli are written into the RAM. To get better reliability a non-coherent dwell is performed. This is done by adding the next 5120 points to the previous 5120 points already present in the RAM. This is repeated for the required number of dwells.

During the last dwell, the maximum detection module 201 finds the maximum in the last 5120 points written to the RAM, and returns the address of this value. This address identifies the slot edge. The correlators can be switched off during this stage.

Step 2: Frame synchronisation and code-group identification

[0222] Each BS belongs to 1 of 32 possible codegroups. Each codegroup uses a different sequence of 16 Cs codes on SCH2. From step1 the position of the secondary codes is known. The decision variables are obtained by non-coherently summing the correlator outputs corresponding to each 16 length sequence out of the 32 possible sequences and its 16 cyclic shifts. One decision variable is formed by adding 16 correlator outputs non-coherently (modulus). The calculation of these 512 values is distributed over the 16 idle intervals (9/10) after each correlation.

By generating the correct x and y (x = phaseshift , y = codegroup number) one of the 6 correlator outputs can be selected and the modulus is calculated. During the first slot, in the idle period, each of the codegroup table entries is selected, this selects 1 of the 6 correlator outputs and the modulus of these are written to one of the 512 used RAM positions during step2. During slot n°2, each

value in the RAM is added with 1 of the 6 correlator modulus outputs of slot2. Which correlator needs to be selected for each RAM address is selected by the x and y combination. This is repeated for the 16 slots, during slot n°16 the resulting values are the 512 decision variables which are sent through the maximum detector.

The address coming from the maximum detection block identifies the codegroup and the phase shift. The frame edge can be determined from the shift.

At least 16 slots have to be added non-coherently.

PRACH TX hardware (Fig. 27)

[0223] One of the general TX channels is used to make the PRACH waveform. In that case the following things are required for the general TX channels :

-An exact and easy way to work in burst mode (eg the use of an activity bit)

-The possibility to 'switch off' and 'switch on' the scramblers at an exact defined time. When the scramblers are turned off, the data must still get the same delay as when the scramblers are turned on.

-An important requirement is that it must be possible to synchronise the PRACH with the received BCCH frame edge + an offset of (access_slot_nr - 1) * 1.25 ms.

Software and interfacing:

[0224] The MS acquires synchronisation to a BS (SCH channel) and reads different parameters from the BCCH channel (preamble spreading codes, available signatures, available access slots, ...). The software 210 decides which parameters to use, these parameters are passed to the hardware via the interface block 211. The start of the

access slot offset must be synchronous with the BCCH frame edge 214.

The upconverter must be set to a Doppler precompensated IF in order to avoid big integration losses in the BS receiver.

Spreaders (212):

[0225] The data coming from the interface block is spread with a max SF of 256. For the access slot offset and the idle period, the activity bit is set to 0. For each of the two branches 256bit RAM is needed to store the PN codes.

Gain stage

[0226] The spread data is sent through a gain block 213. A different gain must be possible for I and Q branch.

CLAIMS

1. A communication device for W-CDMA signal transmission and reception, which is software configurable, comprising:

-a W-CDMA transmitter comprising RAM and/or registers;

-a W-CDMA receiver comprising RAM and/or registers; and

-signal acquisition means,

characterised in that it further comprises a digital circuit for phase unbalance precompensation, said circuit comprising:

- an input register holding the compensation angle,

- means for performing arithmetic to acquire a change of the I,Q angle by the compensation angle.

2. A communication device such as in claim 1, further comprising a circuit for noise and interference estimation, said circuit comprising :

- means to acquire a programmable number of absolute value accumulations at chip rate or oversampled chip rate,

-a programmable low pass filter to average the noise and interference estimations.

3. A communication device such as in claim 1, further comprising a circuit for initial synchronization, said circuit comprising :

-a Matched Filter, energy calculation and accumulating RAM for slot synchronization,

-a set of correlators for frame synchronization & code group identification,

-an energy estimation block,

-Maximum detection means, readable by the microprocessor subsystem.

4. A communication device such as in claim 1, further comprising circuitry to generate packet data transmission, said circuitry comprising :

-A data and activity bits holding buffer,

-I,Q spreaders and gain control means,

-scrambling code generator and scrambling means,

-means for packet timing through RX frame edge triggering.

5. The use of a communication device such as in claim 4, for RACH transmission in UMTS/FDD.

6. A communication device such as any one of claims 1 to 4, further comprising a processor.

7. A communication device such as in claim 6, characterised in that the processor is arranged to reconfigure the communication device.

8. A communication device such as in claim 6 or 7, wherein the processor controls the RAM and/or registers of said W-CDMA signal transmitter and receiver.

9. A communication device such as in any of the claims 6 to 8, characterised in that the transmitter comprises a first programmable pulse shaping filter and that the receiver comprises a second programmable pulse shaping filter.

10. A communication device such as in claim 9, characterised in that the pulse shaping filters are programmable to perform GMSK filtering and said transmitter and receiver are arranged to interface with a GSM front-end.

11. A communication device such as in claim 10, characterised in that the processor performs the GSM protocol stack.

12. A communication device such as in any of the claims 1 to 11, arranged for waveform transmission and/or reception and/or acquisition of signals selected

from the group consisting of UMTS, Satellite UMTS, Galileo, GPS, IS-2000, IMT-2000, CDMA2000, IS-95, 3GPP, 3GPP2 and ARIB signals.

13. The communication device such as in any of the claims 1 to 12, wherein said transmitter comprises one or more elements selected from the group consisting of:

-synchronisation hardware to slave transmit start epochs to events external to the transmitter;

-a burst generator for realising discontinuous transmissions;

-a QPN channel containing one or more spreaders with their own amplification of the output;

-a combiner to accumulate the QPN channel output;

-a PN code generator;

-a scrambling code generator;

-a scrambler;

-a combiner which accumulates the scrambling code output;

-a pulse shaping oversampling filter; and

-an NCO and upconverter for carrier precompensation.

14. A communication device such as in claim 13 wherein the PN code generator is realized as a RAM in which the PN codes are downloaded under control of the processor.

15. A communication device such as in claim 13 or 14, wherein the scrambling code generator is realized as a programmable Gold Code generator.

16. A communication device such as in any of the claims 13 to 15, wherein the QPN channel is arranged to execute UMTS forward or return link transmission.

17. A communication device such as in any of the claims 13 to 16, wherein the amplification of the spreader output is arranged to perform transmit power control.

18. A communication device such as in any of the claims 1 to 17, wherein the transmitter comprises a time interpolator to perform sub-chip time alignments.

19. A communication device such as in any of the claims 1 to 18, wherein the transmitter is arranged for multi-code transmission.

20. A communication device such as in any of the claims 1 to 19, wherein the receiver comprises:

-A pulse shaping filter;

-An optional level control block;

-A demodulator assigned to track the multi-path components received from one base station; and

-A reference demodulator for S/(N+I) measurements.

21. A communication device such as in claim 20, wherein said receiver further comprises a downconverter prior to said pulse shaping filter, in order to interface at a front-end at an intermediate frequency.

22. A communication device such as in claim 20 or 21, wherein the receiver is arranged for execution of UMTS, Satellite UMTS, Galileo, GPS, IS-2000, IMT-2000, CDMA2000, IS-95, 3GPP, 3GPP2 and/or ARIB forward link and return link waveforms.

23. A communication device such as in any of the claims 20 to 22 wherein the level control block comprises:

-a programmable shifter to perform coarse grain dynamic control;

-a programmable multiplier to perform fine grain dynamic control;

-an overflow counter operating on the most significant and the second most significant bit;

-an overflow counter operating on the second most and the third most significant bit;

-saturation logic to clip the result from the multiplier;

24. A communication device such as in any of the claims 20 to 23, wherein the level control block is operated in a runtime control loop by the processor.

25. A communication device such as in any of the claims 20 to 24, wherein the demodulator comprises:

-a Rake filter, producing a signal at chip rate which is a coherent accumulation of channel corrected multipath components resulting from one base station;

-a tracking unit, using said signal at chip rate for descrambling and despreading a plurality of waveform channels; in which said Rake filter comprises:

-a FIFO to buffer samples at chip rate, coming from said level control block of Claim 20;

-a delay line containing a plurality of registers, the input of the delay line being connected to the output of said FIFO;

-a plurality of finger blocks, the inputs of said finger blocks being connected to programmable tap positions on said delay line; and

-a summator of complex outputs of said finger blocks at chip rate.

26. A communication device such as in claim 25, wherein the finger blocks are respectively grouped in a late multipath group and an early multipath group, the Rake filter being arranged to accumulate the energies of the outputs of said late multipath group and said early multipath group, and to use these accumulated values to feed the time error detector of the DLL used for time tracking.

27. A communication device such as in claim 25 or 26, wherein the Rake filter comprises memories to hold one or more of the following:

-spreading code for a channel correction Pilot;

-scrambling code for a channel correction Pilot;

-a channel correction Pilot symbol modulation;

-a channel correction Pilot symbol activities.

28. A communication device such as in claim 27, wherein the memories are controlled by the processor.

29. A communication device such as in claim 27 or 28, wherein the finger block comprises:

-a channel correction Pilot descrambler;

-a channel correction Pilot despreader;

-a channel correction Pilot filter, first performing a coherent channel correction Pilot symbol accumulation over a programmable number of steps, and secondly producing a weighted average on a programmable number of said coherent channel correction Pilot symbol accumulation over a programmable number of steps.

-a channel estimator, generating a channel estimation at chip rate, using the outputs of said Pilot filter;

-a channel corrector, performing a multiplication of the incoming chip stream with the complex conjugate of said channel estimation;

-a calculation of the slot energy;

-a comparison of the slot energy with a programmable threshold;

-a circuit to force said channel estimation to zero if said threshold is not exceeded.

30. A communication device such as in claim 29, wherein the finger is arranged for slow and fast fading compensation, by programming the channel correction Pilot filter for slow fading, said channel correction Pilot filter first performing a coherent accumulation over a slot, and secondly performing a weighted average over previous-previous, previous, actual and next obtained slot

values, yielding a channel estimation per slot, which is applied by said channel corrector; and for fast fading, said channel correction Pilot filter first performing a coherent accumulation over a slot, and then deriving channel estimations through interpolating consecutive said coherent accumulations over a slot, yielding channel estimations with sub-symbol timing, which are applied by said channel corrector.

31. A communication device such as in any of the claims 20 to 30, wherein the reference demodulator comprises:

-an accumulator of programmable length of the absolute values of samples at chip rate; and

-a low pass filter operating on said accumulator output.

32. A communication device such as in any of the claims 20 to 31, wherein the reference demodulator is arranged to operate in a runtime control loop by the processor.

33. A communication device such as in any of the claims 20 to 32, wherein the demodulator is arranged to perform satellite diversity.

34. A communication device such as in any of the claims 1 to 33, arranged to perform accurate ranging measurements to geostationary satellites.

35. An Integrated Circuit comprising the communication device of any of the claims 1 to 34.

36. An Intellectual Property core comprising the communication device of any of the claims 1 to 34.

37. A method for operating a W-CDMA communication device such as in any of the claims 1 to 36, characterised in that it comprises the following steps:

-configuring said device for a specific use, and

-transmitting and/or receiving and/or acquiring waveform signals.

38. Method as in claim 37, characterised in that said waveform signals are selected from the group consisting of UMTS, Satellite UMTS, Galileo, GPS, IS-2000, IMT-2000, CDMA2000, IS-95, 3GPP, 3GPP2 and ARIB signals.

39. Method as in claim 37 or 38, characterised in that said configuring is done by a processor.

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
1 February 2001 (01.02.2001)

PCT

(10) International Publication Number
WO 01/08314 A2

(51) International Patent Classification[7]: H04B

(21) International Application Number: PCT/BE00/00086

(22) International Filing Date: 19 July 2000 (19.07.2000)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
60/145,426 23 July 1999 (23.07.1999) US

(71) Applicant *(for all designated States except US)*: **SIRIUS COMMUNICATIONS N.V.** [BE/BE]; Wingepark 51, B-3110 Rotselaar (BE).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: **LUGIL, Nico** [BE/BE]; Vrouwenparklaan 31, B-3110 Rotselaar (BE). **BORGHS, Eric** [BE/BE]; Kollegestraat 75, B-2440 Geel (BE). **LOUVEAUX, Sébastien** [BE/BE]; Avenue De L'Equerre 25 B302, B-1348 Louvain-La-Neuve (BE). **MERTENS, Carl** [BE/BE]; Het Venneke 2, B-2930 Brasschaat (BE). **PHILIPS, Lieven** [BE/BE]; Kleine Kruisweg 9A, B-3201 Aarschot (BE). **VANDERMOT, Jurgen** [BE/BE]; Diestsestraat 250 B3, B-3000 Leuven (BE). **VANHOOF, Jan** [BE/BE]; Wijgmaalbroeck 59, B-3018 Wijgmaal (BE).

(74) Agents: **VAN MALDEREN, Joëlle et al.**; Office Van Malderen, Place Reine Fabiola, 6/1, B-1083 Brussels (BE).

(81) Designated States *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.

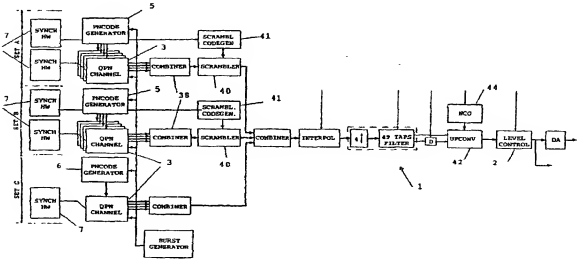
(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published:

— *Without international search report and to be republished upon receipt of that report.*

[Continued on next page]

(54) Title: METHOD AND APPARATUS FOR HIGH-SPEED SOFTWARE RECONFIGURABLE CODE DIVISION MULTIPLE ACCESS COMMUNICATION



(57) Abstract: The present invention is related to a communication device for W-CDMA signal transmission and reception, comprising: a W-CDMA transmitter comprising RAM and/or registers, a W-CDMA receiver comprising RAM and/or registers and signal acquisition means, being software reconfigurable, characterized in that it further comprises at least a digital circuit for phase unbalance precompensation. The present invention further relates to a method for operating a W-CDMA communication device of the present invention, characterised in that it comprises the following steps: configuring said device for a specific use, and transmitting and/or receiving and/or acquiring waveform signals.

WO 01/08314 A2

SET A
SET B
SET C
SYNCH HW
PNCODE GENERATOR
QPN CHANNEL
COMBINER
BURST GENERATOR
SCRAMBL. CODEGEN.
SCRAMBLER
INTERPOL.
49 TAPS FILTER
D
UPCONV.
NCO
LEVEL CONTROL
DA
1
2
3
5
6
7
38
40
41
42
44

FIG. 1

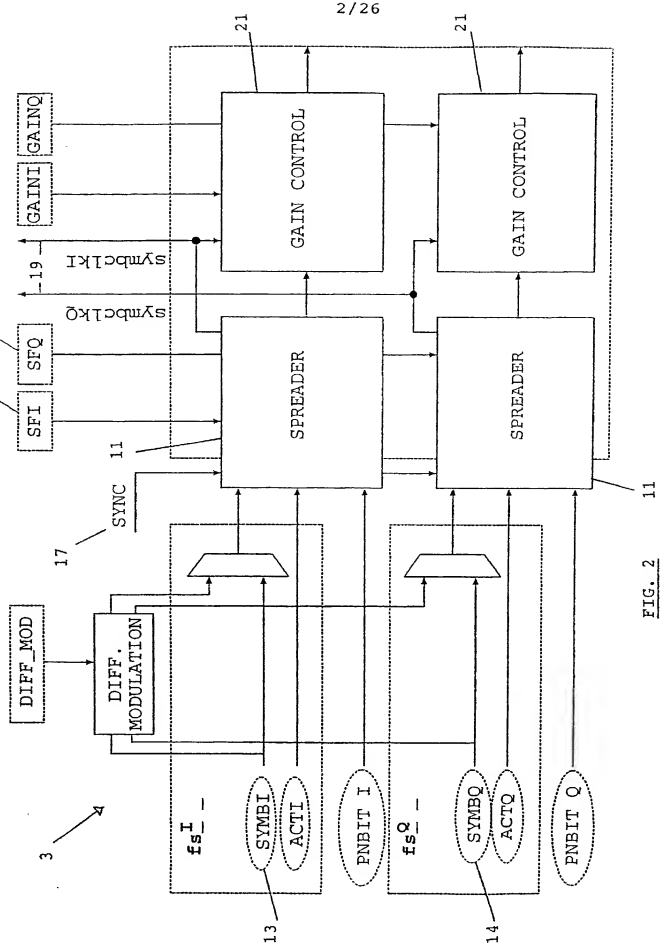

3
DIFF_MOD
DIFF. MODULATION
fsI_
SYMBI
ACTI
PNBIT I
fsQ_
SYMBQ
ACTQ
PNBIT Q
13
14
SYNC
17
SFI
SFQ
15
16
11
SPREADER
SPREADER
symbclkI
symbclkQ
19
GAINI
GAINQ
GAIN CONTROL
GAIN CONTROL
21
21
11

FIG. 2

33
CONFIGURATION
START 25
STOP 27
STEP 29
31
ADDRESS GENERATOR
X
Y
8 x 1024 BIT
SWITCH
23
35

FIG. 3

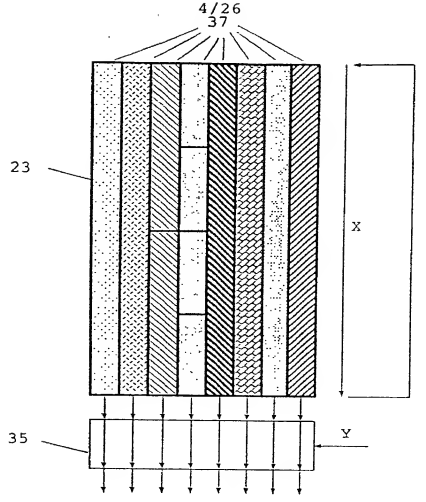


FIG. 4

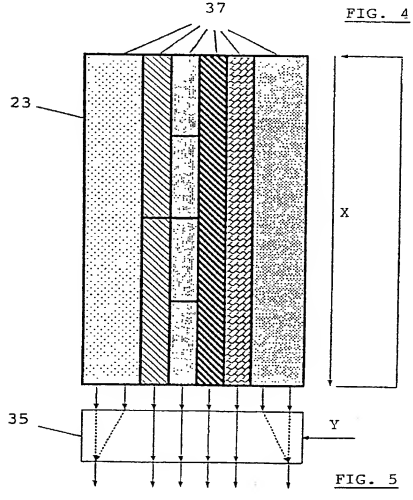


FIG. 5

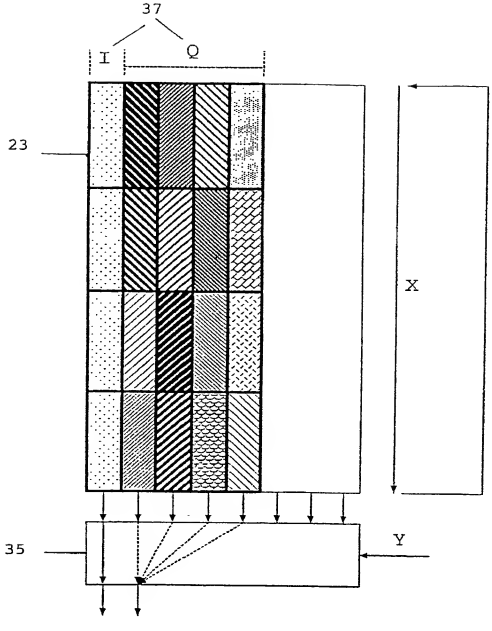


FIG. 6

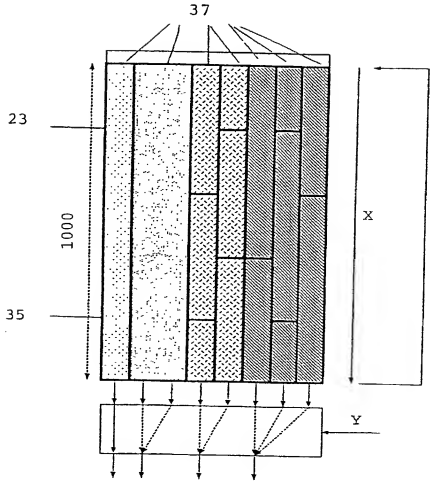


FIG. 7

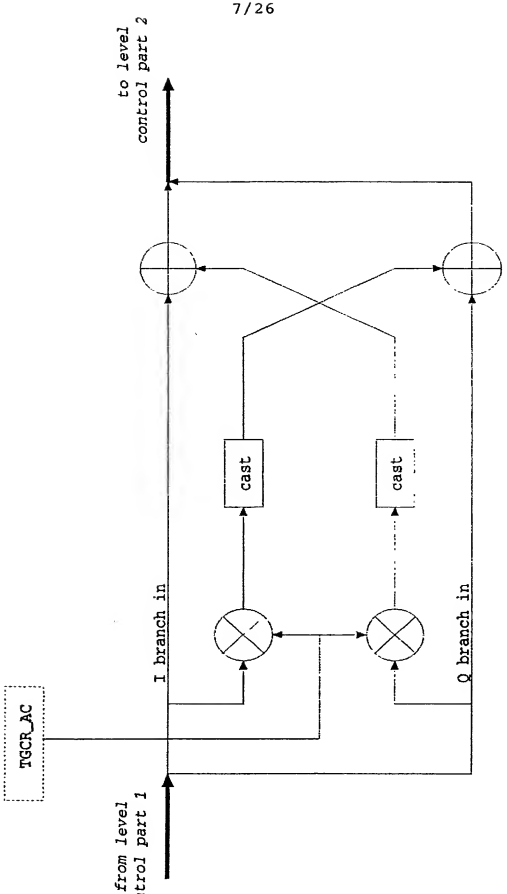

to level control part 2
from level control part 1
TGCR_AC
I branch in
Q branch in
cast
cast

FIG. 8

S/(N+I)
ESTIMATOR
63
DEMODULATOR
67
LEVEL
CONTROL
53
51
PULSE SHAPING
FILTER
49
NCO
47
DOWN-
CONV.
45
43

FIG. 9

10/048142

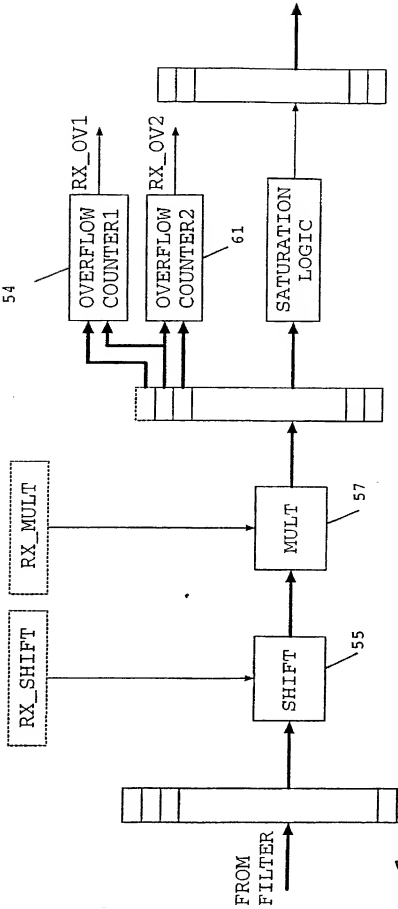


FIG. 10

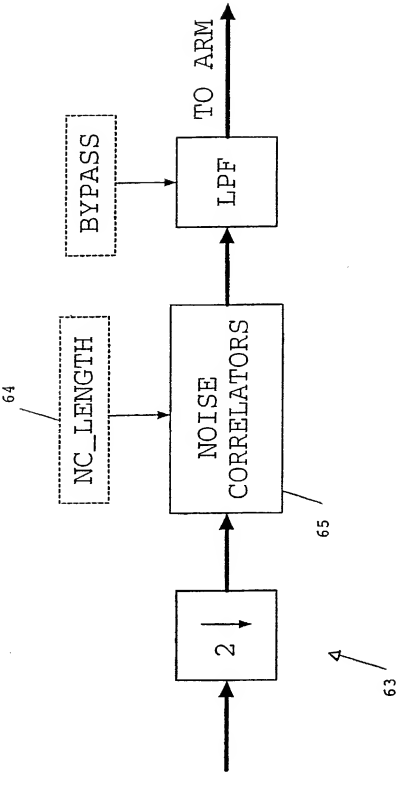


FIG. 11

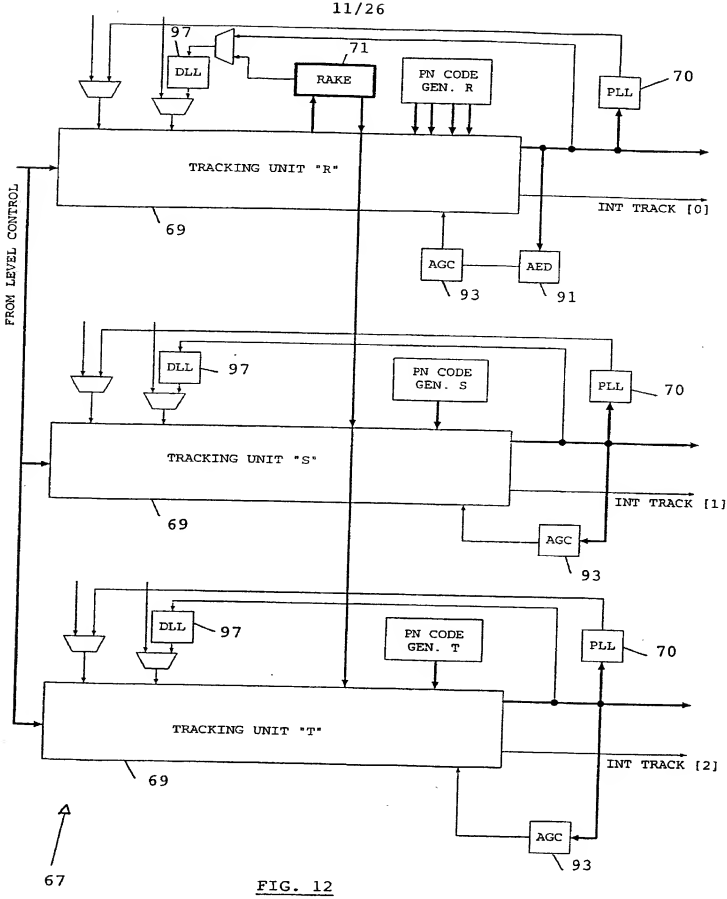

97
71
DLL
RAKE
PN CODE GEN. R
PLL
70
TRACKING UNIT "R"
INT TRACK [0]
69
AGC
AED
93
91
FROM LEVEL CONTROL
DLL
97
PN CODE GEN. S
PLL
70
TRACKING UNIT "S"
INT TRACK [1]
69
AGC
93
DLL
97
PN CODE GEN. T
PLL
70
TRACKING UNIT "T"
INT TRACK [2]
69
AGC
93
67

FIG. 12

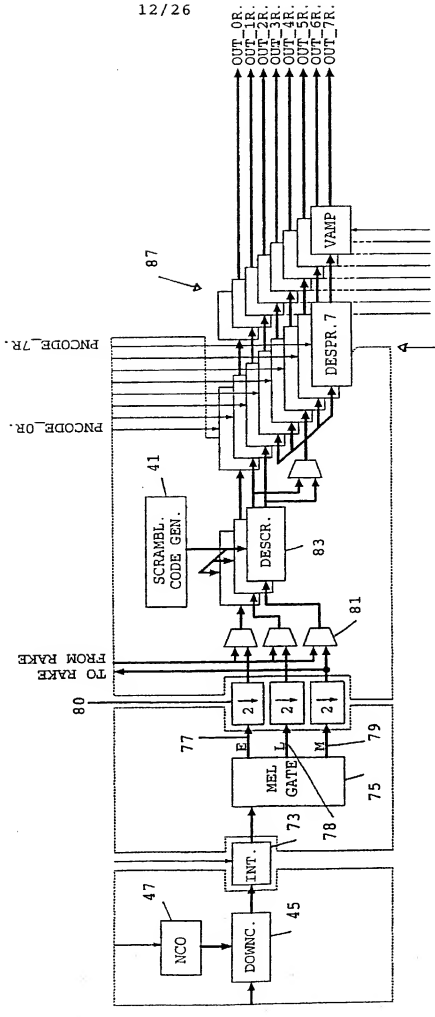

OUT_0R.
OUT_1R.
OUT_2R.
OUT_3R.
OUT_4R.
OUT_5R.
OUT_6R.
OUT_7R.
VAMP
DESPR.7
87
85
PNCODE_7R.
PNCODE_0R.
41
SCRAMBL. CODE GEN.
DESCR.
83
81
TO RAKE
FROM RAKE
80
2:1
77
E
L
M
79
MEL GATE
75
78
73
INT.
47
NCO
DOWNC.
45
69

FIG. 13

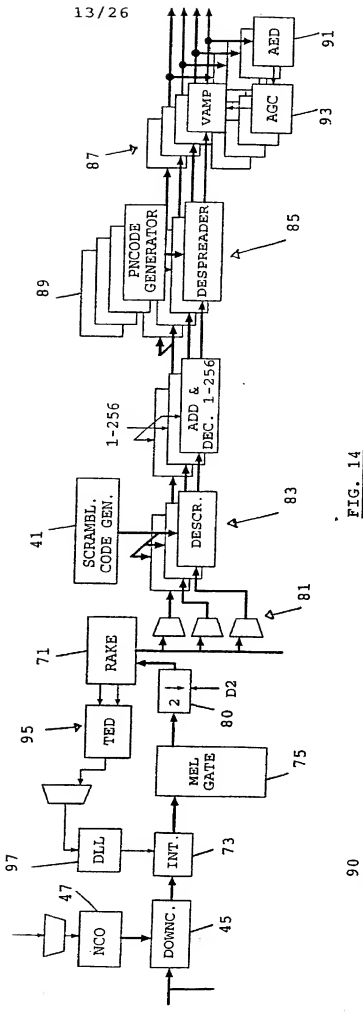

NCO
47
DOWNC.
45
DLL
97
INT.
73
MEL GATE
75
2
D2
80
TED
95
RAKE
71
SCRAMBL. CODE GEN.
41
DESCR.
83
81
1-256
ADD & DEC. 1-256
PNCODE GENERATOR
89
DESPREADER
85
87
VAMP
AGC
93
AED
91
90

FIG. 14

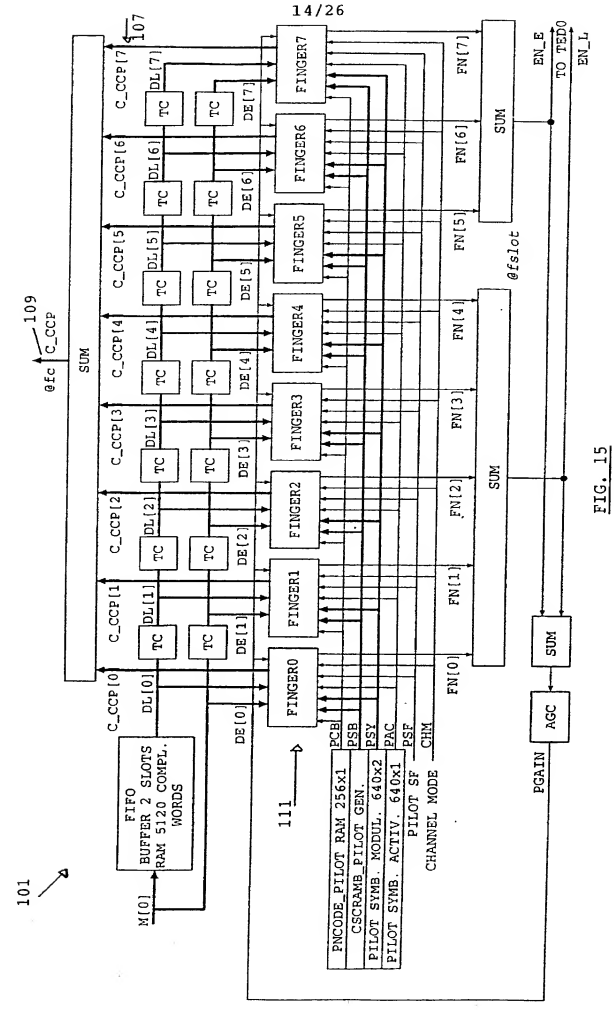

101
M[0]
FIFO
BUFFER 2 SLOTS
RAM 5120 COMPL.
WORDS
111
PNCODE_PILOT RAM 256x1
CSCRAMB_PILOT GEN.
PILOT SYMB. MODUL. 640x2
PILOT SYMB. ACTIV. 640x1
PILOT SF
CHANNEL MODE
PCB
PSB
PSY
PAC
PSF
CHM
109
@fc
C_CCP
SUM
107
C_CCP[0]
C_CCP[1]
C_CCP[2]
C_CCP[3]
C_CCP[4]
C_CCP[5]
C_CCP[6]
C_CCP[7]
DL[0]
DL[1]
DL[2]
DL[3]
DL[4]
DL[5]
DL[6]
DL[7]
TC
DE[0]
DE[1]
DE[2]
DE[3]
DE[4]
DE[5]
DE[6]
DE[7]
FINGER0
FINGER1
FINGER2
FINGER3
FINGER4
FINGER5
FINGER6
FINGER7
FN[0]
FN[1]
FN[2]
FN[3]
FN[4]
FN[5]
FN[6]
FN[7]
SUM
@fslot
AGC
PGAIN
EN_E
TO TED0
EN_L

FIG. 15

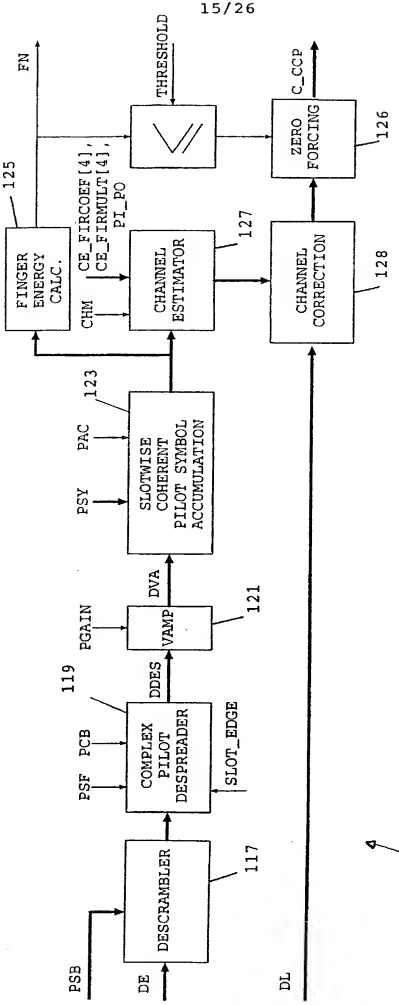

PSB
DE
DESCRAMBLER
117
PSF
PCB
COMPLEX PILOT DESPREADER
SLOT_EDGE
119
DDES
PGAIN
VAMP
121
DVA
PSY
PAC
SLOTWISE COHERENT PILOT SYMBOL ACCUMULATION
123
FINGER ENERGY CALC.
125
CHM
CE_FIRCOEF[4], CE_FIRMULT[4], PI_PO
CHANNEL ESTIMATOR
127
FN
THRESHOLD
DL
CHANNEL CORRECTION
128
ZERO FORCING
126
C_CCP
115

FIG. 16

1 SLOT
P0
P1
P2
P3
P4
P5
P6
P7
DVA
P0
P1
P2
P3
P4
P5
P6
P7
t
t
SP0=(P0U+P1U+P2U+P3U)/4
SP1=(P4U+P5U+P6U+P7U)/4
SP
124

FIG. 17

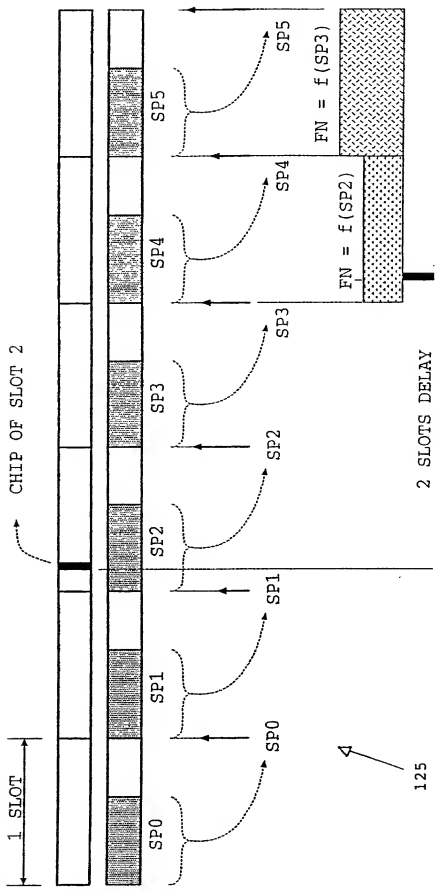

1 SLOT
CHIP OF SLOT 2
SP0
SP1
SP2
SP3
SP4
SP5
SP0
SP1
SP2
SP3
SP4
SP5
FN = f(SP2)
FN = f(SP3)
2 SLOTS DELAY
125

FIG. 18

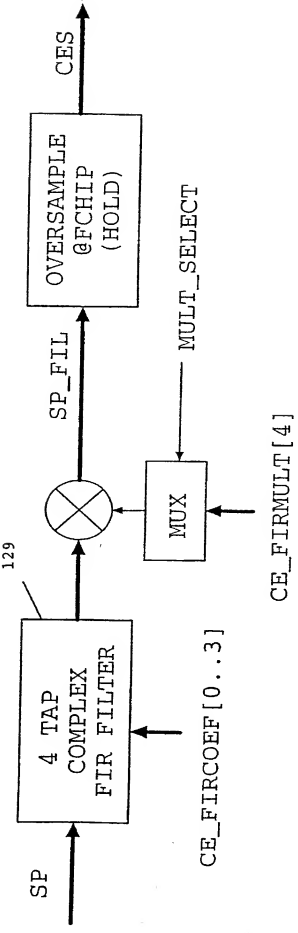

SP
4 TAP
COMPLEX
FIR FILTER
129
CE_FIRCOEF[0..3]
MUX
CE_FIRMULT[4]
SP_FIL
MULT_SELECT
OVERSAMPLE
@FCHIP
(HOLD)
CES

FIG. 19

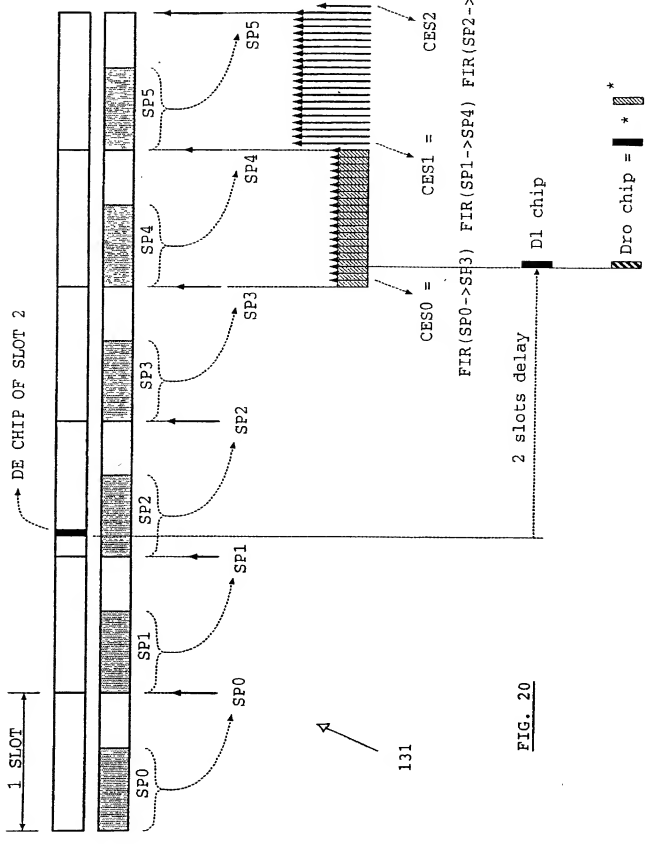

1 SLOT
DE CHIP OF SLOT 2
SP0
SP1
SP2
SP3
SP4
SP5
SP0
SP1
SP2
SP3
SP4
SP5
131
CES0 =
FIR(SP0->SP3)
CES1 =
FIR(SP1->SP4)
CES2 =
FIR(SP2->SP5)
2 slots delay
D1 chip
Dro chip =

FIG. 20

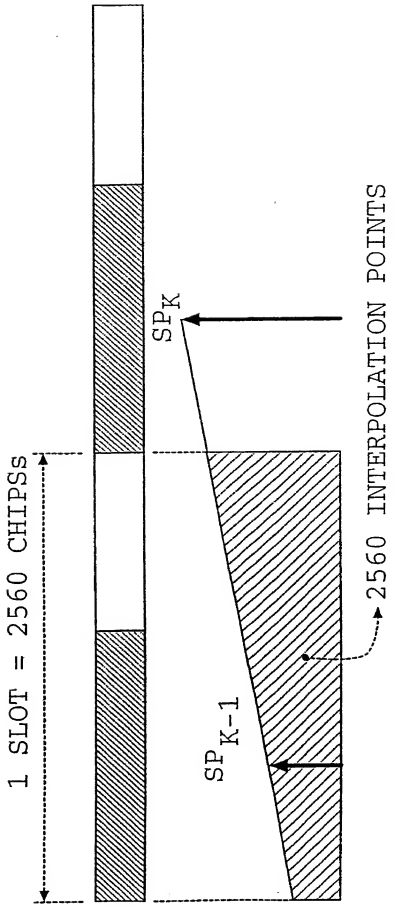


FIG. 21

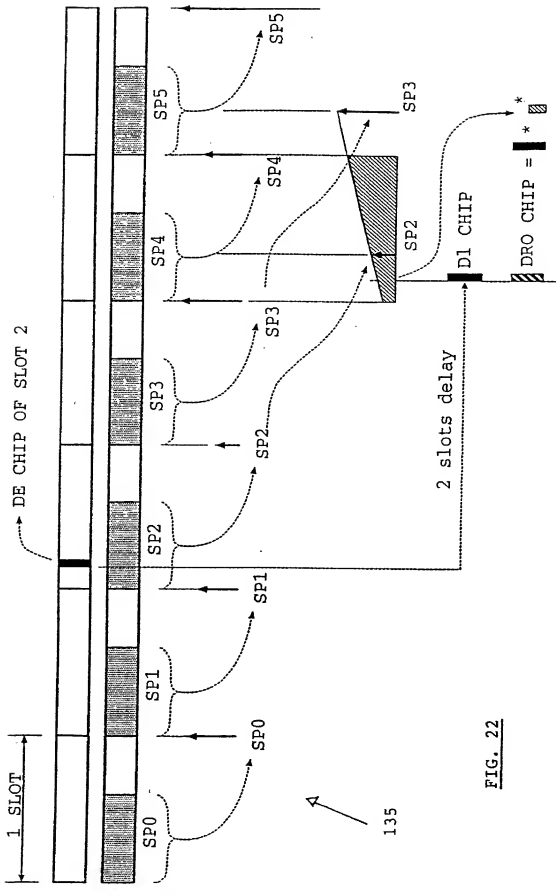

1 SLOT
DE CHIP OF SLOT 2
SP0
SP1
SP2
SP3
SP4
SP5
2 slots delay
D1 CHIP
DRO CHIP =
135

FIG. 22

EP0548145A1 | 1993-06-30

FIG. 23

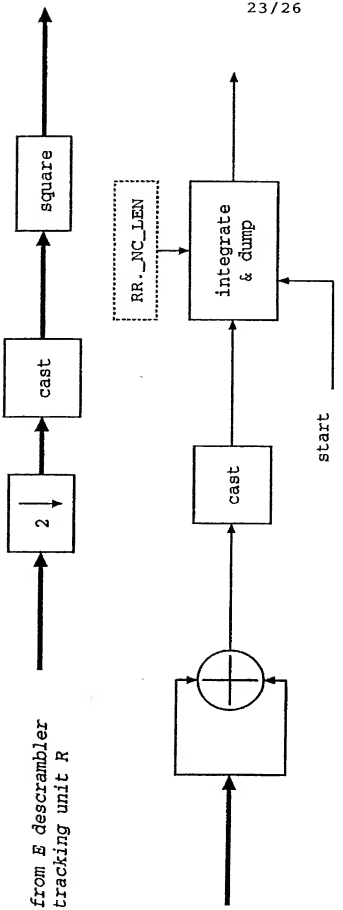

from E descrambler tracking unit R
2
cast
square
cast
integrate & dump
RR._NC_LEN
start
cast
LPF
RR._NC_ALPHA
RR._NC_OUT

FIG. 24

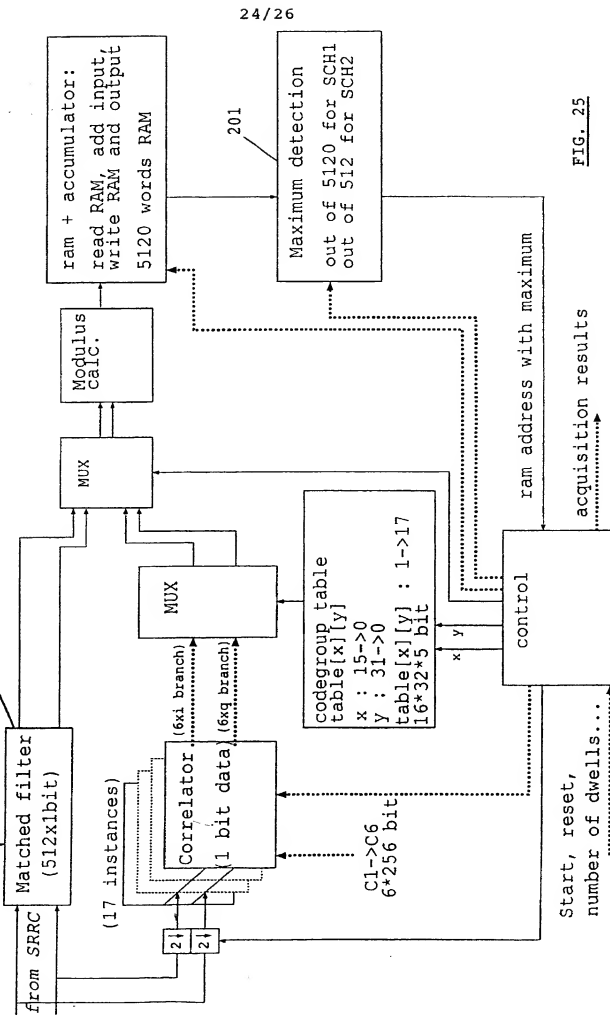

ram + accumulator:
read RAM, add input,
write RAM and output
5120 words RAM
201
Maximum detection
out of 5120 for SCH1
out of 512 for SCH2
Modulus calc.
MUX
MUX
codegroup table
table[x][y]
x : 15->0
y : 31->0
table[x][y] : 1->17
16*32*5 bit
x
y
control
ram address with maximum
acquisition results
Cp (256 bit)
200
Matched filter
(512x1bit)
(17 instances)
Correlator
1 bit data
(6xi branch)
(6xq branch)
C1->C6
6*256 bit
from SRRC
Start, reset,
number of dwells...

FIG. 25

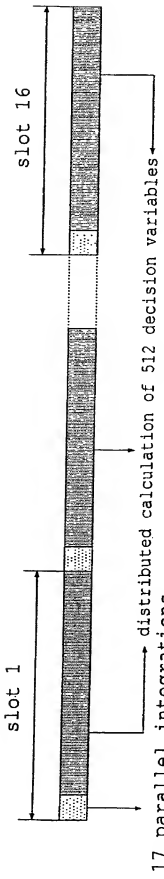

slot 16
distributed calculation of 512 decision variables
slot 1
17 parallel integrations

FIG. 26

FIG. 27

Software
210
Interfacing (+RAM)
211
BCCH frame edge
214
polynomials, inits, startpulse, activity
data, PNcode, activity bit, PN code, SF, synch. info
212
I spreader
Q spreader
I GAIN
Q GAIN
dI
dQ
213
complex scrambling code generator
cI
cQ
Complex Scrambling
dI.cI-dQ.cQ
dI.cQ+dQ.cI
SRRC Filter
Upconv
Level Control
to DA
doppler precompensated IF setting

DECLARATION - USA PATENT APPLICATION

As a below named inventor, I hereby declare that:

My residence, Mailing address and citizenship are as stated below next to my name;

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled METHOD AND APPARATUS FOR HIGH-SPEED SOFTWARE RECONFIGURABLE CODE DIVISION MULTIPLE ACCESS COMMUNICATION the specification of which:

(a) ☐ is attached hereto; or

(b) X was filed on January 22, 2002 as Application No. 10/048,142.

(c) X was described and claimed in PCT International Application No.PCT/BE00/00086 filed on July 19, 2000.

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above;

I acknowledge the duty to disclose information which is material to the patentability of this application in accordance with Title 37, Code of Federal Regulations, § 1.56;

I hereby claim foreign priority benefits under Title 35, United States Code, § 119 of any foreign application(s) for patent, design or inventor's certificate or any PCT international application(s) listed below and have also identified below any foreign application(s) for patent, design or inventor's certificate or any PCT international application(s) designating at least one country other than the United States of America filed for the same subject matter having a filing date before that of the application(s) of which priority is claimed:

PRIOR FOREIGN APPLICATION(S)

COUNTRY (OR INDICATE IF PCT)	APPLICATION NUMBER	DATE OF FILING (day, month, year)	PRIORITY CLAIMED UNDER 35 U.S.C. § 119
			☐ YES NO ☐
			☐ YES NO ☐
			☐ YES NO ☐
			☐ YES NO ☐
			☐ YES NO ☐

I hereby claim the benefit under Title 35, United States Code, § 119(e) of any United States application(s) listed below, and insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code § 112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, § 1.56(a) which occurred between the filing date of the prior application and the national or PCT international filing date of this application:

Prior U.S.A. Application(s)

Application No.: 60/145,426 Filing Date: 23 July 1999 Status: Abandoned

PATENT

ASSIGNMENT

WHEREAS, WE (1) Nico Lugil, a Belgian citizen, residing at Vrouwenparklaan 31, B-3110 Rotselaar, Belgium; (2) Eric Borghs, a Belgian citizen, residing at Kollegstraat 75, B-2440 Geel, Belgium; (3) Sébastien Louveaux, a Belgian citizen, residing at Avenue De L'Equerre 25 B302, B-1348 Louvain-La-Neuve, Belgium; (4) Carl Mertens, a Belgian citizen, residing at Het Venneke 2, B-2930 Brasschaat, Belgium; (5) Lieven Philips, a Belgian citizen, residing at Kleine Kruisweg 9A, B-3201, Aarschot, Belgium; (6) Jurgen Vandermot, a Belgian citizen, residing at Diestsesstraat 250 B3, B-3000 Leuven, Belgium; and (7) Jan Vanhoof, a Belgian citizen, residing at Wijgmaalbroeck 59, B-3018 Wijgmaal, Belgium; hereinafter referred to as Assignor (collectively if more than one inventor is listed above), have invented certain new and useful improvements in METHOD AND APPARATUS FOR HIGH-SPEED SOFTWARE RECONFIGURABLE CODE DIVISION MULTIPLE ACCESS COMMUNICATION, the specification of which:

(a) ☐ was executed on even date herewith;

(b) X was filed on January 22, 2002 as X Application No. 10/048,142.

(c) X was described and claimed in PCT International Application No. PCT/BE00/00086 filed on July 19, 2000.

AND WHEREAS, Sirius Communications N.V., with its principal place of business at Wingepark 51, B-3110 Rotselaar, Belgium, (hereinafter referred to as Assignee) desires to acquire the entire right, title, and interest in and to the said improvements with respect to the United States of America, its territories and possessions.

NOW, THEREFORE, for good and valuable consideration, the receipt and sufficiency of which is hereby acknowledged, Assignor hereby acknowledges that it has sold, assigned, transferred and set over, and by these presents does hereby sell, assign, transfer and set over, unto Assignee, its successors, legal representatives and assigns, the entire right, title, and interest in the United States of America, and its territories and possessions in, to and under said improvements, and any Patent Applications in the United States of America and all divisions, renewals and continuations thereof, and all Patents of the United States of America which may be granted thereon and all reissues and extensions thereof, and all rights of priority under International Conventions; and Assignor hereby authorizes and requests the Commissioner of Patents of the United States of America to issue all Patents for said improvements to Assignee, its successors, legal representatives and assigns, in accordance with the terms of this instrument.

AND ASSIGNOR HEREBY covenants and agrees that it will communicate to Assignee, its successors, legal representatives and assigns, any facts known to it respecting said improvements, and testify in any legal proceeding, sign all lawful papers, execute all divisional, continuing and reissue applications, make all rightful oaths and generally do everything possible to aid Assignee, its successors, legal representatives and assigns, to obtain and enforce proper patent protection for said improvements in the United States of America.

IN TESTIMONY WHEREOF, Assignor intending to be legally bound has hereunto affixed its signature.

This 17th day of June, 2002

Signature of Nico Lugil

Witnessed by:

- DO NOT RECORD -

This 17th day of June, 2002

Signature of Eric Borghs

Witnessed by: Frank Vem de Saude

This 17th day of June, 2002

Signature of Sébastien Louveaux

Witnessed by: Frank Vem de Saude

This 17th day of June, 2002

Signature of Carl Mertens

Witnessed by: Frank Vem de Saude

This 17th day of June, 2002

Signature of Lieven Philips

Witnessed by: Frank Vem de Saude

This 17th day of June, 2002

Signature of Jurgen Vandermeir

Witnessed by:

This 17th day of June, 2002

Signature of Jan Vanhoof

Witnessed by: Frank Vem de Saude

H:\DOCS\MOH\MOH-7316 DOC ad
040802

COPY
- DO NOT RECORD -

Citizenship: Belgian

Mailing Address: Same as above.

6-00 Full name of sixth inventor: Jurgen Vandermot

Inventor's signature _____ Day 17 Month June Year 2002

Residence (city and country): Diestsestraat 250 B3, B-3000 Leuven, Belgium BEX

Citizenship: Belgian

Mailing Address: Same as above.

7-00 Full name of seventh inventor: Jan Vanhoof

Inventor's signature _____ Day 17 Month June Year 2002

Residence (city and country): Wijgmaalbroeck 59, B-3018 Wijgmaal, Belgium BEX

Citizenship: Belgian

Mailing Address: Same as above.

Send Correspondence To:
KNOBBE, MARTENS, OLSON & BEAR, LLP
Customer No. 20,995

H:\DOCS\MOH\MOH-7315.DOC:ad
040802

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful, false statements may jeopardize the validity of the application or any patent issued thereon.

1-00 Full name of first inventor: Nico Lamli

Inventor's signature _____ Day 17 Month June Year 2002

Residence (city and country): Vrouwenparklaan 31, B-3110 Rotselaar, Belgium BEX

Citizenship: Belgian

Mailing Address: Same as above.

2-00 Full name of second inventor: Eric Borghs

Inventor's signature _____ Day 17 Month June Year 2002

Residence (city and country): Kollegestraat 75, B-2440 Geel, Belgium BEX

Citizenship: Belgian

Mailing Address: Same as above.

3-00 Full name of third inventor: Sébastien Louveaux

Inventor's signature _____ Day 17 Month June Year 2002

Residence (city and country): Avenue De L'Equerre 25 B302, B-1348 Louvain-La-Neuve, Belgium BEX

Citizenship: Belgian

Mailing Address: Same as above.

4-00 Full name of fourth inventor: Carl Mertens

Inventor's signature _____ Day 17 Month June Year 2002

Residence (city and country): Het Venneke 2, B-2930 Brasschaat, Belgium BEX

Citizenship: Belgian

Mailing Address: Same as above.

5-00 Full name of fifth inventor: Lieven Philips

Inventor's signature _____ Day 17 Month June Year 2002

Residence (city and country): Kleine Kruisweg 9A, B-3201, Aarschot, Belgium BEX

ESTABLISHMENT OF RIGHT OF ASSIGNEE TO TAKE ACTION
AND
REVOCATION AND POWER OF ATTORNEY

To the Commissioner of Patents and Trademarks:

The undersigned is empowered to act on behalf of the assignee indicated below (the "Assignee"). The original assignment of the attached application for Letters Patent for the invention in METHOD AND APPARATUS FOR HIGH-SPEED SOFTWARE RECONFIGURABLE CODE DIVISION MULTIPLE ACCESS COMMUNICATION from the inventors to the Assignee is being submitted herewith for recordation by the Assignment Branch. A true copy of this Assignment is attached hereto. This Assignment represents the entire chain of title of this invention from the Inventor(s) to the Assignee. I have reviewed this Assignment, and to the best of the Assignee's knowledge and belief, the Assignee is the owner of the entire right, title, and interest in the above-referenced application.

I declare that all statements made herein of my own knowledge are true, and that all statements made upon information and belief are believed to be true, and further, that these statements were made with the knowledge that willful, false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S.C. § 1001, and that willful, false statements may jeopardize the validity of the application, or any patent issuing thereon.

The undersigned hereby revokes any previous powers of attorney in the subject application, and hereby appoints the registrants of Knobbe, Martens, Olson & Bear, LLP, 620 Newport Center Drive, Sixteenth Floor, Newport Beach, California 92660, Telephone (949) 760-0404, **Customer No. 20,995**, as its attorneys with full power of substitution and revocation to prosecute this application and to transact all business in the U.S. Patent and Trademark Office connected herewith. This appointment is to be to the exclusion of the inventor(s) and his attorney(s) in accordance with the provisions of 37 C.F.R. § 3.71.

Please use **Customer No. 20,995** for all communications.

Assignee: Sirius Communications N.V.

By: _____

Title: Lieven Philips, CEO

Address: Wingepark 51
B-3110 Rotselaar, Belgium

Dated: 17th June 2002

H:\DOCS\MOH\MOH-7317.DOC:ad
040802